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(54) Title: SEMAPHORIN MODULATION OF IMMUNE CELL MIGRATION

(57) Abstract: The present invention is directed to compositions and methods for use in immunotherapeutic treatment of immune cell migration-mediated diseases or conditions, including the following: auto-immune; hypersensitivity or neoplastic diseases or conditions such as cancers; and food intolerance. Also encompassed by the invention are methods and compositions for use in promoting or suppressing angiogenesis. The compositions and methods disclosed involve the use of semaphorin polypeptides and semphorin receptor polypeptides, which function to influence immune cell migration.

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## SEMAPHORIN MODULATION OF IMMUNE CELL MIGRATION

This application claims priority to United States provisional patent application serial number 60/152,915 filed September 8, 1999, now abandoned; and United States provisional patent application serial number 60/172,877, filed December 20, 1999, now abandoned.

### 5 I. FIELD OF THE INVENTION

The present invention is directed to compositions and methods useful in immunotherapeutics. The agents used in these compositions and methods are semaphorin polypeptides, including semaphorin receptor polypeptides, that, through receptor-mediated activity, function to direct migration of immune cells.

### 10 II. BACKGROUND OF THE INVENTION

The semaphorin gene family includes, to date, over twenty molecules that encode related transmembrane and secreted glycoproteins known to be neurologic regulators. Semaphorins are generally well conserved in their extracellular domains, which are typically about 500 amino acids in length, and are best known in the field of neurobiology as chemorepulsive molecules that work with chemoattractants to  
15 direct the migration of developing axons (Tessier-Lavigne, M and Goodman C.S., 1996). Semaphorins have been studied largely for their role in neuronal growth cone guidance. For example, the secreted semaphorins known as collapsin-1 and Drosophila semaphorin II are selectively involved in repulsive growth cone guidance during development. Flies having mutated to display reduced activity of semaphorin II genes exhibit abnormal behavior characteristics.

20 Mammalian (human, rat, and mouse) semaphorin genes have also been identified, based upon their similarity to insect semaphorins. Functional studies of these semaphorins suggest that embryonic and adult neurons require a semaphorin to establish workable connections. Significantly, the fast response time of growth cone cultures to appropriate semaphorins suggests that semaphorin signaling involves a receptor-mediated signal transduction mechanism. Accordingly, it is speculated that semaphorin ligands secreted  
25 into the extracellular milieu signal through receptor bearing cells in a localized and systemic fashion.

In addition to insect and mammalian semaphorin genes, viral semaphorin genes have also been identified. One viral semaphorin gene is found in several strains of poxvirus including both the vaccinia virus (Copenhagen strain) and Ectromelia virus, and is encoded in an open reading frame (ORF) known as A39R. The A39R-encoded semaphorin protein is a secreted protein, with no transmembrane domain and  
30 no potential membrane linkage. The variola virus ORF, contains sequences that share homology with the vaccinia virus ORF A39R at the nucleotide level and the amino acid level. Another viral semaphorin, AHV-sema, has been found in the Alcelaphine Herpesvirus (AHV).

Mammalian systems are able to develop acquired or specific immunity in response to pathogens. In this manner, mammalian systems are able to specifically recognize and selectively eliminate or protect  
35 against foreign microorganisms and molecules (antigens). Controlled manipulation of such a system

would allow one to direct the immune system in particularly efficient or advantageous ways, such as, for example, to specifically target or eliminate diseases that are regulated by the immune system.

One aspect of the immune response involves the interaction between T-lymphocytes, or "T cells," and immune cells known as antigen presenting cells (APCs). T lymphocytes originate from hematopoietic stem cells, and migrate to the thymus gland to mature. Once mature, T cells express a receptor which only allows recognition of antigens that are processed and complexed with specific cell membrane associated proteins known as Class II major histocompatibility complex (MHC) molecules. When an immunologically naïve T cell encounters a cell presenting a Class II MHC-antigen combination, the T cell proliferates and differentiates into other forms of T cells, including memory T cells, T-helper ( $T_H$ ) cells, and T cytotoxic ( $T_C$ ) cells.  $T_H$  cells also recognize Class II MHC-antigen combinations. Upon such recognition, the  $T_H$  cells are activated to release various cytokines. Under the influence of such  $T_H$  cell-derived cytokines, T cells that recognize class I MHC-antigen combinations proliferate and differentiate into cytotoxic T lymphocytes (CTLs). Subsequent steps in the immune cascade follow from these initiating steps.

It is important that regulation of  $T_H$  cells be scrupulously specific and controlled, because  $T_H$  cell-derived cytokines are required and are in fact critical to both humoral and cell-mediated immune responses. An important part of  $T_H$  cell regulation involves the fact that  $T_H$  cells can only recognize antigen in conjunction with class II MHC on the surface of APCs. APC mobility, or chemotaxis, is therefore critical to proper function of this important aspect of the immune system. Control of the ability of an APC to migrate to present antigen to immunologically naïve T-cells would allow control of induction of the immune response and, logically, the control of many immune-cell mediated disease pathways. For example, prevention of APC emigration and homing to draining lymph nodes will prevent the induction of the APC-mediated immune responses such as those relative to localized inflammatory responses and autoimmune diseases. Alternatively, promotion of APC migration to draining lymph nodes would accelerate immune responses to specific antigens, thus could be used to promote immunity to, for example, specific tumor antigens which would promote tumor immunity and prevent tumor cell proliferation.

Another type of immune cell involved in immune system-mediated disease, in particular hypersensitivity disorders such as allergies or urticaria, are mast cells. Mast cells are found throughout connective tissues, particularly near blood and lymphatic vessels. Some tissues, including the skin and mucous membrane surfaces of the respiratory and gastrointestinal tract, contain high concentrations of mast cells per  $\text{mm}^3$ . When activated, these cells migrate to a site of inflammation and release a variety of pharmacologically active substances, such as histamines and cytokines, from their granules. The release of such substances by mast cells results in the manifestation of a variety of hypersensitivity disorders. Control of mast cell migration would permit the promotion or suppression of release of the pharmacologically active substances they contain, and thus would facilitate control of mast cell-mediated hypersensitivity reactions. For example, promotion of mast cell migration to an area of inflammation in a

patient that suffers from an immune deficiency will allow for promotion of an immune response where needed. Alternatively, suppression of mast cell migration to a site of over-inflammation will prevent deleterious compounding of the immune response. Mast cells are also immune cells involved in the formation of new vasculature. Accordingly, if a method were developed by which mast cell migration  
5 could be controlled, it would also allow for the manipulation of angiogenesis.

Recent work has focused on the effect of semaphorins on immune responses. Various investigators have explored the relationship between semaphorins and the immune system and have theorized that semaphorins may somehow function to suppress the immune response in various systems (see, eg. PCT Publication No. WO 99/32622, incorporated herein by reference) and, in particular, may  
10 operate by inducing cytokine activity (see, copending application serial number 08/958,598, incorporated herein by reference, in its entirety). Elucidating other specific relationships between semaphorins and the immune system would prove helpful in the development of useful immuno-therapeutic compositions and methods employing semaphorins. For example, many mammalian diseases, such as auto-immune diseases cancer and hypersensitivity disorders, involve various aspects of the immune response system, and in  
15 particular, involve the migration of immune cells. Accordingly, directed or specific control of migration of cells of the immune system would provide a means for therapeutically treating such conditions.

### III. SUMMARY OF THE INVENTION

The present invention provides a novel means of using semaphorins or semaphorin receptor polypeptides to treat disorders mediated by the immune system including cancers by controlling immune  
20 cell chemotaxis. Preferred semaphorins include AHV Sema, A39R, Sema I, including G-sema I and D-sema-I; Sema II; Sema III; Sema IV; DC Sema; CD100; Z SMF-7; Sema A: Sema B: Sema C; Sema D; Sema E; Sema H; Sema L; Sema W and Sema Y, as well as semaphorin fragments, such as the sema domain of these semaphorins. Preferred semaphorin receptor polypeptides include the Viral-Encoded Semaphorin Receptor ("VESPR") and soluble fragments thereof. Using semaphorins or their receptors, or  
25 antibodies to these, the present invention provides compositions and methods for the treatment of immune cell mediated conditions or disorders. Examples of such conditions or disorders include those resulting in an inflammatory response, especially those that are T-cell-mediated, such as auto-immune disorders; cancers such as tumors or diffuse neoplasms, including metastatic neoplasms; hypersensitivity diseases or conditions; conditions associated with deficient vascularization or hypervascularization; and those  
30 associated with food allergies.

In one aspect, the present invention provides pharmaceutical compositions and methods for the treatment of a tumor in a mammal. In these embodiments, the invention comprises use of an amount of a semaphorin, or an amount of a soluble semaphorin receptor polypeptide, such as soluble VESPR, or an amount of an antibody to a semaphorin polypeptide receptor such as VESPR, such that administration of  
35 an amount of the composition is effective to inhibit progression, or to produce regression or destruction, in whole or in part, of the tumor. Use of such a method or composition according to the present invention can

also inhibit metastasis of the tumor in the patient. Specific tumors that may be treated with such a composition include virtually any type of tumor, especially those associated with organs, such as liver or colon tumors, or other discrete tissues, such as melanoma. Tumors may be malignant or otherwise cancerous, or benign, so long as they are characterized by an abnormal proliferation of cells.

5 In another embodiment, the present invention provides a pharmaceutical composition and method for the treatment of a neoplasm in a mammal. When used in this application, the invention comprises an amount of a semaphorin, or an amount of a soluble semaphorin receptor polypeptide such as soluble VESPR or an amount of an antibody to a semaphorin receptor polypeptide such as VESPR, such that  
10 administration of an amount of said composition is effective to inhibit progression, or to produce regression or destruction, in whole or in part, of the target neoplasm. Neoplasms that may be treated with the present compositions include metastatic neoplasms, diffuse cancers such as lymphoma or leukemia, or any other manner of systemic proliferation of cancerous cells.

In yet another preferred embodiment, the present invention provides a method or a pharmaceutical composition for the treatment of a mammal with an auto-immune or hypersensitivity disorder or condition,  
15 where the auto-immune or hypersensitivity disorder or condition is characterized by an inflammatory response. When used in this application the composition of the present invention includes an amount of a semaphorin, or an amount of a soluble semaphorin receptor polypeptide such as soluble VESPR, or an amount of an antibody to a semaphorin polypeptide receptor such as VESPR, such that administration of an amount of said composition is effective to ameliorate or eliminate, in whole or in part, the inflammation  
20 associated with the auto-immune or hypersensitivity disorder or condition. Auto-immune disorders that may be treated with the presently disclosed methods and compositions include rheumatoid arthritis, osteoarthritis, lupus erythematosus, asthma, multiple sclerosis, or any other immune disorder involving immune recognition and targeting of self cells or tissues and resulting in one or more inflammatory responses. Hypersensitivity disorders that may be treated with the presently disclosed compositions and  
25 methods include allergies; urticaria, including urticaria in response to pressure, heat, or cold; eczema; and contact dermatitis.

Another aspect of the present invention provides for compositions and methods of promoting or suppressing angiogenesis in a subject. In this aspect, the invention comprises administering to the subject an amount of a semaphorin, or a soluble semaphorin receptor polypeptide such as soluble VESPR or an  
30 amount of an antibody to a semaphorin receptor polypeptide such as VESPR, effective to promote or suppress angiogenesis. This method is contemplated to be useful in controlling angiogenesis in a wide variety of circumstances. For example, the disclosed methods and compositions may be used to promote vascular development in patients that have suffered a stroke or severe tissue damage, such as occurs during organ transplantation, heart muscle damage, limb reattachment, organ resection or other trauma.  
35 Alternatively, the disclosed compositions and methods, such as by use of a semaphorin or an antibody to

VESPR, can suppress angiogenesis or disrupt vascular development in disfavored tissue such as tumor tissue.

In another aspect, the present invention provides a method and composition, adapted for the treatment of a food allergy or food intolerance in a mammal. In this embodiment, the method or  
5 composition employs a semaphorin, or a soluble semaphorin receptor polypeptide such as soluble VESPR, or an antibody to a semaphorin receptor polypeptide such that administration of the composition is effective to ameliorate or eliminate, in whole or in part, the food allergy or intolerance. Exemplary food allergies or intolerances that may be treated with such a composition include allergies to general classes of foods, such as dairy products or wheat products, or to treat allergies or intolerances to specific foods. The  
10 present invention also provides a method of treating such food allergies or intolerances, in which the method includes administration of a semaphorin-containing, or soluble semaphorin receptor polypeptide-containing composition to the patient suffering from the food allergy or intolerance. In a preferred embodiment, the composition contains soluble VESPR.

Formulation of any of the presently disclosed compositions may be done by any manner known to  
15 those of skill in the art. Such formulations will vary according to variables such as, for example, the needs of the formulator, the intended route of administration, the targeted disease or tissue, and the subject being treated. Specifically, the composition may be formulated in multi-dose containers including additives such as a carrier, other excipients, and a preservative component.

The presently disclosed compositions may also be in virtually any form including an aqueous  
20 solution, a suspension, a lyophilized form that may be reconstituted when appropriate, a gel, an aerosol, a transdermal patch or any other form or state convenient for administration to treat the described disorders.

The compositions as described herein may be formulated so that they are contained in a vial, bottle, tube, syringe inhaler or other container for single or multiple administrations. Such containers may be made of glass or a polymer material such as polypropylene, polyethylene, or polyvinylchloride, for  
25 example. Preferred containers may include a seal, or other closure system, such as a rubber stopper that may be penetrated by a needle in order to withdraw a single dose and then re-seal upon removal of the needle. All such containers for injectable liquids, lyophilized formulations, reconstituted lyophilized formulations or reconstitutable powders for injection known in the art or for the administration of aerosolized compositions are contemplated for use in the presently disclosed compositions and methods..

In alternative embodiments, the presently disclosed methods and compositions further comprise  
30 use or administration of additional active agents such as chemotherapeutic agents, immune suppressants or radiation therapy. For example, agents that may be useful according to the disclosed methods and compositions include virtually any chemotherapeutic agent such as taxotere, doxorubicin, cis-platin, tamoxifen, i-phosphamide, or methotrexate, or variants of any of these compounds. Alternatively or  
35 additionally, the presently disclosed methods and compositions may further be used in conjunction with an

immune suppressant, such as a cytokine, IL-4, IL-12, GM-CSF, G-CSF, M-CSF,  $\alpha$ -interferon,  $\beta$ -interferon, or  $\gamma$ -interferon.

In an alternative embodiment, the present invention provides a method of screening for a VESPR ligand or other molecule or substance that influences the ability of immune cells to migrate. In other words, a method of identifying VESPR agonists or antagonists. In one embodiment, such a method includes the following steps: (1) contacting a first immune cell comprising a VESPR with a test compound in the presence of a semaphorin; (2) measuring the migration of the first immune cell; and (3) comparing the migration of the first immune cell to migration of a control cell, under comparable conditions in the absence of a test compound. When these steps are followed, the resulting cell migration is observed, with a difference in the motility of the first immune cell relative to the control cell being indicative of an effector of migration of an immune cell. The effector so identified may be either a promoter or a suppressor of immune cell migration.

Alternatively, a VESPR ligand or other molecule or substance that influences immune cell chemotaxis can be identified *via* the following method: (1) contacting an immune cell comprising a VESPR with a test compound in the presence of a known chemokine; (2) measuring the migration of the immune cell; and (3) comparing the migration of the immune cell to migration of a control cell, wherein said control cell is observed under comparable conditions, in the absence of a test compound. When these steps are followed, the resulting cell motility is observed, with a difference in the motility of the immune cell relative to the control cell being indicative of a VESPR ligand or other molecule or substance that functions as an effector of motility of an immune cell. Such screening methods are useful for identifying both promoters and inhibitors of immune cell migration.

In another aspect, the present invention provides a therapeutic package for dispensing to, or for use in dispensing to, a mammal diagnosed with a tumor; a metastatic neoplasm; an auto-immune or hypersensitivity disease or condition characterized at least in part by an inflammatory response; a food allergy or intolerance; or in a mammal in which promotion or inhibition of angiogenesis is desired. Such a therapeutic package will include (1) one or more doses, each such dose comprising at least a semaphorin, a soluble VESPR polypeptide, or an antibody to a semaphorin receptor polypeptide, and (2) a finished pharmaceutical container therefore. In such a package, the amount of semaphorin, soluble VESPR polypeptide, or antibody to a semaphorin receptor polypeptide in the dose or doses is effective, upon administration to the mammal, to inhibit progression, or to produce regression or destruction, in whole or in part, of the tumor or neoplasm; or to ameliorate or eliminate, in whole or in part, the inflammation or food allergy or intolerance; or to promote or inhibit angiogenesis. The finished pharmaceutical container for such a package will contain the dose or doses, and will further contain or comprise labeling directing the use of the package in the treatment of the mammal.

In all aspects of the present invention, it is specifically contemplated that the disclosed compositions and methods are useful to treat the targeted conditions in virtually any mammal, and in particular, they are useful for the treatment of targeted diseases in humans.

#### IV. BRIEF DESCRIPTION OF THE DRAWINGS

5 **Figure 1:** These data show that the semaphorin A39R inhibits both spontaneous migration of monocytes, as well as monocyte migration towards the monocyte-attracting chemokine MCP-1 (as shown in lines -▲- and -◆-). These data also show that VESPR mediates this inhibitory effect of the semaphorin. M460 is a blocking mAb directed against VESPR. According to these results, M460 partially reverses the inhibitory effects of A39R (see line -Δ-). Further confirming the role of VESPR is the data showing that  
10 M461, a non-blocking mAb against VESPR and having the same isotype as M460, does not influence the inhibitory effect of the semaphorin (see line -◇-).

**Figure 2:** These data show the results of the under agarose assays, indicating that migration of immune cells, specifically APCs, in the presence of semaphorin, is inhibited. The bottom frame shows diffuse cells in assay lacking chemokines; the middle frame shows that, in the presence of A39R and  
15 MCP1, the cells do not migrate toward the chemo-attractant MCP1, while in the top frame, cells are clearly drawn towards MCP1 in the absence of the semaphorin A39R.

**Figure 3:** These data show that semaphorins, or semaphorin-receptor complexes influence immune cell motility, but are not lethal to the cells. An increase in fluorescence over time shows that the cells are viable. Cells exposed to A39R remain viable (see lines -●-, -□-, -○-, and -◇-). These data confirm  
20 that, in cases such as where monocyte migration is inhibited, this immobilization is not the result of cell death.

**Figure 4:** These data show the *in vivo* immune cell migration in the presence of semaphorin, as compared to migration in control animals. Specifically, Langerhans cell migration to regional lymph nodes (upper right quadrant) in A39R-treated animals and control animals is set forth, indicating that, *in vivo*,  
25 semaphorins inhibit APC migration to regional lymph nodes (MHC class II positive, FITC positive, compare 9.19% in control animals to 6.21% in semaphorin treated animals).

#### V. DETAILED DESCRIPTION OF THE INVENTION

Surprisingly, the present invention shows that semaphorins or semaphorin receptors are specifically useful in immune cell regulation because of their influence on immune cell chemotaxis. It is  
30 further shown in the present invention that this effect on the motility or migration of immune cells by semaphorins is receptor-mediated.

The following words have the following meanings when used herein:

Antigen Presenting Cell (APC): any cell that can process or present antigenic peptides in association with class II major histocompatibility complex (MHC) molecules. APCs can also deliver a co-  
35 stimulatory signal necessary for T-cell activation. APCs may be cells that almost always process or



present class II MHCs, or are involved in T-cell activation such as macrophages; dendritic cells such as, for example, Langerhans cells and B-cells. Alternatively, some cells may be induced to express class II MHC and to deliver a co-stimulatory signal to T-cells, and thus are APCs if only for a short period of time. These cells include fibroblasts, glial cells, pancreatic beta cells, thymic epithelial cells, thyroid epithelial cells, and vascular endothelial cells. Any cell that either processes or presents class II MHC, or plays a role in T-cell activation, is contemplated to be an APC for purposes of this invention.

Mast Cell: immune system cells involved in various immune system responses, including allergic and hypersensitivity responses, and containing large numbers of cytoplasmic granules comprising pharmacologically active substances such as histamine.

Pharmaceutically acceptable carrier- includes any and all solvents, dispersion media, coatings, antibacterial, isotonic and absorption delaying agents, buffers, excipients, flavorings, binders, lubricants, gels, surfactants and the like, that may be used as a media for a pharmaceutically acceptable substance.

Viral Encoded Semaphorin Protein Receptor (VESPR) Polypeptide: a VESPR polypeptide, as that term is used herein, is any polypeptide functioning as a receptor for viral semaphorins, for human homologues to viral semaphorins, or for human semaphorins. Specific VESPR-encoding nucleic acid sequences and various forms of VESPR polypeptides are described in copending application S/N 08/958,598, (specifically incorporated herein by reference in its entirety).

Immune cell migration-mediated disease or condition: When used herein this term refers to those diseases or physical states that are dependent upon the migration of immune cells, in particular APCs and mast cells as well as other immune cells the migration of which is influenced by semaphorins or semaphorin receptors. Specific examples of such diseases or conditions include auto-immune diseases or conditions, hypersensitivity diseases or conditions, neoplastic diseases or conditions, food allergies or intolerances, and those diseases or conditions characterized in part by deficient vascularization or hypervascularization.

AutoImmune diseases or conditions: Autoimmune disorders are those involving immune cell recognition and targeting of self cells or tissues and resulting in one or more inflammatory responses. Examples of such diseases or conditions include rheumatoid arthritis, osteoarthritis, lupus erythematosus, asthma, and multiple sclerosis.

Hypersensitivity diseases or conditions: Hypersensitivity disorders are those conditions characterized by either a delayed or an immediate exaggerated response to a foreign stimulus or stimuli. Examples of hypersensitivity diseases or conditions include contact dermatitis; urticaria, including urticaria in response to pressure, heat, or cold; eczema; and allergies.

Inflammatory response: The terms inflammatory response and inflammation refer to the pathological process occurring in blood vessels and tissues in response to injury or stimulation caused by a physical, chemical, or biological agent. Inflammation or inflammatory responses are characterized by one

or more of the following non-exhaustive list of symptoms: redness of the affected tissue; heat; swelling; pain; lost function of the tissue or cells affected; contraction of smooth muscle and dilation of capillaries due to release by immune cells of pharmacologically active agents; and development of wheals or hives.

Neoplastic disease or condition: Neoplastic diseases or conditions are those characterized by an  
5 abnormal proliferation of cells, generally due to cells continuing to replicate after the stimuli that initiated growth has ceased. Neoplastic diseases or conditions include those in which the abnormal cell proliferation is confined to a specific area or tissue in the body, such as in a confined tumor of an organ or tissue; those that occur in a more diffuse manner throughout the affected subject, such as in the case of leukemia or lymphoma; and those in which the abnormal proliferation of cells spreads or migrates to other  
10 tissues or areas of the body, in other words, metastatic cell proliferation.

#### A. SEMAPHORINS AND SEMAPHORIN RECEPTORS

The present invention is based on the interaction between semaphorins or their agonists or antagonists, and semaphorin receptors, either membrane-bound or soluble.

The present invention contemplates the use of virtually any semaphorin for use in the disclosed  
15 compositions and methods. Specific semaphorins that may be used according to the present invention include the viral semaphorins such as Sema IV from both vaccinia and variola viruses, A39R, and AHV-sema. Alternatively those semaphorins cited in the following references are specifically contemplated to be useful according to the present invention: Goodman *et al.*, U.S. Patent No. 5,935,865; Dodd and Schuchardt, 1995); EP 945,505; EP 933,425; EP 960,888; EP 960,937; and WO 99/32622. Such  
20 semaphorins include, but are not limited to: Sema I, including G-sema I and D-sema-I; Sema II; Sema III; Sema IV; DC Sema; CD100; Z SMF-7; Sema A; Sema B; Sema C; Sema D; Sema E; Sema H; Sema L; Sema W and Sema Y.

Additionally, it is specifically contemplated that fragments of these semaphorins, such as, for example, the fragments including the sema domain or the active domain will be useful according to the  
25 present invention, as will fusion proteins encompassing a semaphorin or semaphorin fragment. For example, the DC sema fusion proteins described in co-pending PCT patent application No. PCT/US99/09831, which was filed as a provisional in the United States, as Provisional Application Serial No. 60/085,497 (specifically incorporated herein by reference) will be useful. For additional semaphorins that can be used in the presently disclosed compositions and methods, *see* Bamberg, *et.al.* Cell, 97:551 and  
30 United States Patent No. 5,935,865 to Goodman *et al.* Nucleic acid sequences encoding the semaphorins or semaphorin fragments of the present invention, are also specifically contemplated to be useful in the disclosed compositions and methods.

Semaphorin receptors or semaphorin receptor polypeptides are known to be various molecules including those identified as neuropilins or plexins (*see, Comeau, et al.*, April 1998). Plexins contain a  
35 "sema" domain that is related to the sema domain of semaphorins themselves, part of which constitutes a series of two or three cystein repeat sequences in the extracellular domain of plexins. Plexins are distinct

from semaphorins, however, in a variety of respects. For example, in their intracellular domain, plexins are strongly homologous throughout the family of plexins, and contain well-conserved amino acid motifs that are not found in semaphorins.

Semaphorin receptors of the present invention are those plexin polypeptide sequences that can  
5 interact with a semaphorin or a semaphorin fragment, to influence immune cell migration. Exemplary semaphorin receptor polypeptides include full-length plexin receptor polypeptides as well as homologues or fragments, such as the soluble extra cellular domain or the sema domain of such plexin receptor polypeptides. An exemplary Plexin receptor is the Viral Encoded Semaphorin Protein Receptor "VESPR," (described in copending patent application serial number 08/958,598). Specifically the amino acid  
10 sequence of SEQ ID NO:2 is useful as a semaphorin receptor polypeptide in the presently disclosed compositions and methods, as are the homologues and variants of polypeptides of SEQ ID NO:2. In particular, the present invention contemplates the use of fragments of VESPR, such as the soluble fragment of VESPR. An example of a soluble VESPR receptor polypeptide includes amino acids 1-944 of SEQ ID NO:2. In addition, truncated soluble VESPR proteins comprising less than the entire extracellular domain  
15 are included in the invention, *e.g.*, amino acids 35-944.

Also encompassed within the present invention are the nucleic acid sequences encoding such useful VESPR receptor polypeptides and polypeptide fragments. Nucleic acid sequences encoding the semaphorin receptors or receptor fragments are also within the scope of the presently disclosed compositions and methods. Particularly preferred nucleic acid sequences include the polynucleotide  
20 sequence of SEQ ID NO:1; and those segments of SEQ ID NO:1 that encode the soluble fragments of VESPR outlined above.

The semaphorin or semaphorin receptor polypeptides of the invention may be membrane bound or they may be secreted and thus soluble. Soluble polypeptides are capable of being secreted from the cells in which they are expressed. In general, soluble polypeptides may be identified (and distinguished from non-  
25 soluble membrane-bound counterparts) by separating intact cells which express the desired polypeptide from the culture medium, *e.g.*, by centrifugation, and assaying the medium (supernatant) for the presence of the desired polypeptide. The presence of polypeptide in the medium indicates that the polypeptide was secreted from the cells and thus is a soluble form of the protein.

In one embodiment, the soluble polypeptides and fragments thereof comprise all or part of the  
30 extracellular domain, but lack the transmembrane region that would cause retention of the polypeptide on a cell membrane. A soluble polypeptide may include the cytoplasmic domain, or a portion thereof, as long as the polypeptide is secreted from the cell in which it is produced. In general, the use of soluble forms is advantageous for certain applications. Purification of the polypeptides from recombinant host cells is facilitated, since the soluble polypeptides are secreted from the cells. Further, soluble polypeptides are  
35 generally more suitable for intravenous administration.

The invention also provides polypeptides and fragments of the extracellular domain that retain a desired biological activity. Particular embodiments are directed to polypeptide fragments that retain the ability to interact with the semaphorin receptor or ligand to influence immune cell migration. Such a fragment may be a soluble polypeptide, as described above. In another embodiment, the polypeptides and fragments advantageously include regions that are conserved in the semaphorin family, in the case of semaphorins; or regions that are conserved in the plexin family in the case of the semaphorin receptors; or include the sema domain of either.

Also provided herein are polypeptide fragments comprising at least 20, or at least 30, contiguous amino acids of the sequence of SEQ ID NO:2. Fragments derived from the cytoplasmic domain find use in studies of signal transduction, and in regulating cellular processes associated with transduction of biological signals. Polypeptide fragments also may be employed as immunogens, in generating antibodies.

Naturally occurring variants as well as derived variants of the polypeptides and fragments are provided herein. Variants may exhibit amino acid sequences that are at least 80% identical. Also contemplated are embodiments in which a polypeptide or fragment comprises an amino acid sequence that is at least 90% identical, at least 95% identical, at least 98% identical, at least 99% identical, or at least 99.9% identical to the preferred polypeptide or fragment thereof. Percent identity may be determined by visual inspection and mathematical calculation. Alternatively, the percent identity of two protein sequences can be determined by comparing sequence information using the GAP computer program, based on the algorithm of Needleman and Wunsch (J. Mol. Bio. 48:443, 1970) and available from the University of Wisconsin Genetics Computer Group (UWGCG). The preferred default parameters for the GAP program include: (1) a scoring matrix, blosum62, as described by Henikoff and Henikoff (Proc. Natl. Acad. Sci. USA 89:10915, 1992); (2) a gap weight of 12; (3) a gap length weight of 4; and (4) no penalty for end gaps. Other programs used by one skilled in the art of sequence comparison may also be used.

The variants of the invention include, for example, those that result from alternate mRNA splicing events or from proteolytic cleavage. Alternate splicing of mRNA may, for example, yield a truncated but biologically active protein, such as a naturally occurring soluble form of the protein. Variations attributable to proteolysis include, for example, differences in the N- or C-termini upon expression in different types of host cells, due to proteolytic removal of one or more terminal amino acids from the protein (generally from 1-5 terminal amino acids). Proteins in which differences in amino acid sequence are attributable to genetic polymorphism (allelic variation among individuals producing the protein) are also contemplated herein.

Additional variants within the scope of the invention include polypeptides that may be modified to create derivatives thereof by forming covalent or aggregative conjugates with other chemical moieties, such as glycosyl groups, lipids, phosphate, acetyl groups and the like. Covalent derivatives may be prepared by linking the chemical moieties to functional groups on amino acid side chains or at the N-

terminus or C-terminus of a polypeptide. Conjugates comprising diagnostic (detectable) or therapeutic agents attached thereto are contemplated herein, as discussed in more detail below.

Other derivatives include covalent or aggregative conjugates of the polypeptides with other proteins or polypeptides, such as by synthesis in recombinant culture as N-terminal or C-terminal fusions.

- 5 Examples of fusion proteins are discussed below in connection with oligomers. Further, fusion proteins can comprise peptides added to facilitate purification and identification. Such peptides include, for example, poly-His or the antigenic identification peptides described in U.S. Patent No. 5,011,912 and in Hopp et al., *Bio/Technology* 6:1204, 1988. One such peptide is the FLAG<sup>®</sup> peptide, Asp-Tyr-Lys-Asp-Asp-Asp-Lys, which is highly antigenic and provides an epitope reversibly bound by a specific
- 10 monoclonal antibody, enabling rapid assay and facile purification of expressed recombinant protein. A murine hybridoma designated 4E11 produces a monoclonal antibody that binds the FLAG<sup>®</sup> peptide in the presence of certain divalent metal cations, as described in U.S. Patent 5,011,912, hereby incorporated by reference. The 4E11 hybridoma cell line has been deposited with the American Type Culture Collection under accession no. HB 9259. Monoclonal antibodies that bind the FLAG<sup>®</sup> peptide are available from
- 15 Eastman Kodak Co., Scientific Imaging Systems Division, New Haven, Connecticut.

Among the variant polypeptides provided herein are variants of native polypeptides that retain the native biological activity or the substantial equivalent thereof. One example is a variant that binds with essentially the same binding affinity as does the native form. Binding affinity can be measured by conventional procedures, *e.g.*, as described in U.S. Patent No. 5,512,457 and as set forth below.

- 20 Variants include polypeptides that are substantially homologous to the native form, but which have an amino acid sequence different from that of the native form because of one or more deletions, insertions or substitutions. Particular embodiments include, but are not limited to, polypeptides that comprise from one to ten deletions, insertions or substitutions of amino acid residues, when compared to a native sequence.

- 25 A given amino acid may be replaced, for example, by a residue having similar physiochemical characteristics. Examples of such conservative substitutions include substitution of one aliphatic residue for another, such as Ile, Val, Leu, or Ala for one another; substitutions of one polar residue for another, such as between Lys and Arg, Glu and Asp, or Gln and Asn; or substitutions of one aromatic residue for another, such as Phe, Trp, or Tyr for one another. Other conservative substitutions, *e.g.*, involving
- 30 substitutions of entire regions having similar hydrophobicity characteristics, are well known.

Similarly, the DNAs of the invention include variants that differ from a native DNA sequence because of one or more deletions, insertions or substitutions, but that encode a biologically active polypeptide.

- 35 The invention further includes polypeptides of the invention with or without associated native-pattern glycosylation. Polypeptides expressed in yeast or mammalian expression systems (*e.g.*, COS-1 or COS-7 cells) can be similar to or significantly different from a native polypeptide in molecular weight and

glycosylation pattern, depending upon the choice of expression system. Expression of polypeptides of the invention in bacterial expression systems, such as *E. coli*, provides non-glycosylated molecules. Further, a given preparation may include multiple differentially glycosylated species of the protein. Glycosyl groups can be removed through conventional methods, in particular those utilizing glycopeptidase. In general, glycosylated polypeptides of the invention can be incubated with a molar excess of glycopeptidase (Boehringer Mannheim).

Correspondingly, similar DNA constructs that encode various additions or substitutions of amino acid residues or sequences, or deletions of terminal or internal residues or sequences are encompassed by the invention. For example, N-glycosylation sites in the polypeptide extracellular domain can be modified to preclude glycosylation, allowing expression of a reduced carbohydrate analog in mammalian and yeast expression systems. N-glycosylation sites in eukaryotic polypeptides are characterized by an amino acid triplet Asn-X-Y, wherein X is any amino acid except Pro and Y is Ser or Thr. Appropriate substitutions, additions, or deletions to the nucleotide sequence encoding these triplets will result in prevention of attachment of carbohydrate residues at the Asn side chain. Alteration of a single nucleotide, chosen so that Asn is replaced by a different amino acid, for example, is sufficient to inactivate an N-glycosylation site. Alternatively, the Ser or Thr can be replaced with another amino acid, such as Ala. Known procedures for inactivating N-glycosylation sites in proteins include those described in U.S. Patent 5,071,972 and EP 276,846, hereby incorporated by reference.

In another example of variants, sequences encoding Cys residues that are not essential for biological activity can be altered to cause the Cys residues to be deleted or replaced with other amino acids, preventing formation of incorrect intramolecular disulfide bridges upon folding or renaturation.

Other variants are prepared by modification of adjacent dibasic amino acid residues, to enhance expression in yeast systems in which KEX2 protease activity is present. EP 212,914 discloses the use of site-specific mutagenesis to inactivate KEX2 protease processing sites in a protein. KEX2 protease processing sites are inactivated by deleting, adding or substituting residues to alter Arg-Arg, Arg-Lys, and Lys-Arg pairs to eliminate the occurrence of these adjacent basic residues. Lys-Lys pairings are considerably less susceptible to KEX2 cleavage, and conversion of Arg-Lys or Lys-Arg to Lys-Lys represents a conservative and preferred approach to inactivating KEX2 sites.

Encompassed by the invention are oligomers or fusion proteins that contain semaphorin or semaphorin receptor polypeptides. Such oligomers may be in the form of covalently-linked or non-covalently-linked multimers, including dimers, trimers, or higher oligomers. As noted above, preferred polypeptides are soluble and thus these oligomers may comprise soluble polypeptides. In one aspect of the invention, the oligomers maintain the binding ability of the polypeptide components and provide therefor, bivalent, trivalent, etc., binding sites.

One embodiment of the invention is directed to oligomers comprising multiple polypeptides joined via covalent or non-covalent interactions between peptide moieties fused to the polypeptides. Such

peptides may be peptide linkers (spacers), or peptides that have the property of promoting oligomerization. Leucine zippers and certain polypeptides derived from antibodies are among the peptides that can promote oligomerization of the polypeptides attached thereto, as described in more detail below.

As one alternative, an oligomer is prepared using polypeptides derived from immunoglobulins.

- 5 Preparation of fusion proteins comprising certain heterologous polypeptides fused to various portions of antibody-derived polypeptides (including the Fc domain) has been described, *e.g.*, by Ashkenazi et al. (*PNAS USA* 88:10535, 1991); Byrn et al. (*Nature* 344:677, 1990); and Hollenbaugh and Aruffo ("Construction of Immunoglobulin Fusion Proteins", in *Current Protocols in Immunology*, Suppl. 4, pages 10.19.1 - 10.19.11, 1992).

- 10 One embodiment of the present invention is directed to a dimer comprising two fusion proteins created by fusing a polypeptide of the invention to an Fc polypeptide derived from an antibody. A gene fusion encoding the polypeptide/Fc fusion protein is inserted into an appropriate expression vector. Polypeptide/Fc fusion proteins are expressed in host cells transformed with the recombinant expression vector, and allowed to assemble much like antibody molecules, whereupon interchain disulfide bonds form  
15 between the Fc moieties to yield divalent molecules.

The term "Fc polypeptide" as used herein includes native and mutein forms of polypeptides made up of the Fc region of an antibody comprising any or all of the CH domains of the Fc region. Truncated forms of such polypeptides containing the hinge region that promotes dimerization are also included. Preferred polypeptides comprise an Fc polypeptide derived from a human IgG1 antibody.

- 20 One suitable Fc polypeptide, described in PCT application WO 93/10151 (hereby incorporated by reference), is a single chain polypeptide extending from the N-terminal hinge region to the native C-terminus of the Fc region of a human IgG1 antibody. Another useful Fc polypeptide is the Fc mutein described in U.S. Patent 5,457,035 and in Baum et al., (*EMBO J.* 13:3992-4001, 1994) incorporated herein by reference. The amino acid sequence of this mutein is identical to that of the native Fc sequence  
25 presented in WO 93/10151, except that amino acid 19 has been changed from Leu to Ala, amino acid 20 has been changed from Leu to Glu, and amino acid 22 has been changed from Gly to Ala. The mutein exhibits reduced affinity for Fc receptors.

The above-described fusion proteins comprising Fc moieties (and oligomers formed therefrom) offer the advantage of facile purification by affinity chromatography over Protein A or Protein G columns.

- 30 In other embodiments, the polypeptides of the invention may be substituted for the variable portion of an antibody heavy or light chain. If fusion proteins are made with both heavy and light chains of an antibody, it is possible to form an oligomer with as many as four semaphorin or semaphorin receptor extracellular regions. Alternatively, the oligomer is a fusion protein comprising multiple polypeptides, with or without peptide linkers (spacer peptides). Among the suitable peptide linkers are those described  
35 in U.S. Patents 4,751,180 and 4,935,233, which are hereby incorporated by reference. A DNA sequence encoding a desired peptide linker may be inserted between, and in the same reading frame as, the DNA

sequences of the invention, using any suitable conventional technique. For example, a chemically synthesized oligonucleotide encoding the linker may be ligated between the sequences. In particular embodiments, a fusion protein comprises from two to four soluble semaphorin or semaphorin receptor polypeptides, separated by peptide linkers.

5 Another method for preparing the oligomers of the invention involves use of a leucine zipper. Leucine zipper domains are peptides that promote oligomerization of the proteins in which they are found. Leucine zippers were originally identified in several DNA-binding proteins (Landschulz et al., *Science* 240:1759, 1988), and have since been found in a variety of different proteins. Among the known leucine zippers are naturally occurring peptides and derivatives thereof that dimerize or trimerize. Zipper domains  
10 (also referred to herein as an oligomerizing, or oligomer-forming, domain) and their use are well-known in the art.

Alternatively, agonists or antagonists of semaphorins, including antibodies (both monoclonal and polyclonal) viruses and small molecule agonists or antagonists will be useful according to the present invention. Further contemplated to be useful in the presently disclosed invention are agonists or antagonists  
15 of the interaction between a semaphorin receptor polypeptide such as VESPR and a semaphorin. For example, antibodies to semaphorin receptor polypeptides, such as VESPR antibodies, are specifically contemplated to be useful according to the present invention. Methods of identifying and utilizing such agonists or antagonists are well-known in the art.

#### B. SEMAPHORINS INFLUENCE MIGRATION OF IMMUNE CELLS

20 The present invention is concerned with the receptor-mediated influence of semaphorins, semaphorin agonists such as agonistic antibodies, or semaphorin antagonists, on cells of the immune system such as antigen presenting cells and mast cells. Two techniques prove particularly helpful in elucidating the mechanism of this influence: the transwell migration assay (Boyden Chamber, Boyden S.J.; Baum, J. et. al., (1971); Keller, H.U. et. al.; Snyderman, R. et. al.; Zigmond, S.H. et. al.; Gallin, J.I., et. al.,  
25 and the under-agarose assay (Nelson, R.D. et. al.). Using these assays, the present invention shows that semaphorins exhibit profound effects on cell migration, specifically on the migration of APCs and mast cells, either when used alone in culture, or in combination with known chemoattractants.

A39R, a viral semaphorin, proves a useful semaphorin to show this effect. In the transwell migration assay, human or mouse APCs are loaded with a fluorescent dye and seeded into the upper  
30 chamber of a transwell apparatus. This apparatus consists of two chambers stacked vertically, and separated by a porous filter. Medium, chemoattractants (such as chemokines), or other chemokinetic factors are placed in the bottom chamber, and the migration of APCs across the porous membrane is measured on a fluorescent plate reader in real time. In this assay, the presence of A39R alone in the lower chamber abolishes all spontaneous migration of antigen presenting cells through the membrane, and when  
35 placed in the bottom chamber along with chemokines that facilitate the movement of APCs, A39R



significantly interferes with the movement of APC across the membrane in response to the chemoattractant.

**C. SEMAPHORINS ALLOW MANIPULATION OF IMMUNE CELL MIGRATION *IN VITRO* AND *IN VIVO***

5 The present invention further provides a means of manipulating APC migration when a semaphorin is administered along a "gradient." To illustrate this, the effects of A39R on APC migration, when the semaphorin is presented to cells along a "gradient" (concentration) were determined, via the under-agarose assay. In this experiment, a petri dish is coated with medium-containing agarose. When this layer hardens, a line of three small, uniform holes are punched in the agarose. Cells are seeded into the  
10 center well, chemoattractants or other chemokinetic reagents are seeded into an adjacent well, and medium is seeded into the third well as a control. The assay is monitored over a period of time by light microscopy. Responsive APC move in a directional fashion, under the agarose, toward a chemoattractant and can be photographed using photomicroscopy over a period of time. In these assays, A39R dramatically interfered with the migration of the APC toward a chemoattractant, when placed in the same well, at the same time,  
15 as the chemoattractant. Additionally, A39R placed alone in a well adjacent to seeded APC caused significant APC movement, but in either a non-directional fashion, or in a direction that was away from the source of A39R. Results are shown in Figure 2.

In both the transwell assay as well as the under-agarose assay, appropriate controls consisting of heat inactivated, or heterologous proteins were included. In the case of human monocytes, the experiments  
20 have been performed on no less than five donors, in excess of three times for each donor. Experiments using blocking monoclonal antibodies against the Immunex proprietary molecule VESPR, the receptor for the semaphorin A39R, have indicated that the effects of the viral semaphorin on cell migration are mediated through VESPR.

The present invention specifically contemplates that the disclosed compositions and methods will  
25 be effective when administered to a patient. *In vivo* cell migration assays were performed to illustrate this utility. Drawing on similar experiments to assess the role of cytokines such as IL-10 or TNF in Langerhans cell migration, *in vivo* assays were constructed. Specifically, Langerhans cells provided a useful experimental system to confirm that semaphorins elicit a local effect on antigen presenting cell migration. Results showed that local administration of semaphorin effects skin APC migration to regional  
30 lymph nodes. The results of such assays are shown in Figure 4.

Given this result, the present invention shows that the binding or other interaction between a semaphorin, such as the viral semaphorin A39R, its human homologue, or any agonistic antibody or small molecule, and VESPR, inhibits the movement of an APC towards any area where it might encounter a Tcell, which would then recognize the presented antigen, or encounter an other responsive cell that might  
35 be effected by monokine production. The T cell or other responsive cell would be prevented from responding according to its immune system role, such as by proliferating, producing cytokines, promoting

the function of B-cells, other T cells, or Natural Killer (NK) cells, macrophages or any other cell that responds to cytokines. The present invention further teaches that mast cell migration is influenced by the interaction between a semaphorin such as the viral semaphorin A39R, its human homologue, or any agonistic antibody or small molecule, and VESPR. Thus, mast cell migration to site of inflammation, and  
5 release of the granular contents of the mast cell can be controlled *via* manipulation of the semaphorin-receptor interaction.

Specific examples of how administration of a semaphorin or semaphorin receptor or antagonist or agonist of either might be used as an immunotherapeutic includes treatment of an auto-immune or hypersensitivity diseases or conditions; treatment of neoplastic diseases or conditions; treatment of food  
10 allergies or intolerances and promotion or suppression of angiogenesis.

**1. Semaphorins and Semaphorin Receptors Can Be Used To Treat Auto-immune or Hypersensitivity Disorders**

Using a semaphorin to inhibit APC migration, would allow minimization of the amount of self antigen presented to T cells, thus inhibiting proliferation of self-reactive T cells, and inhibiting production  
15 of pro-inflammatory cytokines. Any semaphorin agonist identified by the processes disclosed herein, would function equally well in this manner. Additionally or alternatively, the interaction between semaphorins and their receptors, or agonists or antagonists of this interaction can be used to influence mast cell migration to treat autoimmune or hypersensitivity disorders or conditions such as various forms of arthritis, lupus, multiple sclerosis, allergies, urticaria, eczema or dermatitis. For example, an agonistic  
20 antibody to VESPR, or a soluble semaphorin that binds VESPR can be administered to interfere with the migration of mast cells to sites of inflammation, thus reducing the allergic, urticaric, asthmatic or other hypersensitivity or autoimmune response.

Alternatively, as another example, targeted delivery of a soluble version of VESPR can also facilitate the migration of mast cells into an area of inflammation to promote a chemokine driven immune  
25 response. This sort of treatment would be useful in instances where the immune response is deficient or suppressed, such as when the subject suffers from an immunodeficiency disease or has suppressed immune response due to concurrent or previous therapeutic regimens, such as in the case of patients undergoing cancer chemotherapy.

**30 2. Semaphorins and Semaphorin Receptors Can Be Used To Treat Neoplastic Diseases**

Additionally, semaphorins or semaphorin receptors, or agonists or antagonists of their interaction may be used to regulate the immune cascade and treat cancer or other neoplastic diseases. One form of such immunotherapy would involve, for example, presentation of the naturally-occurring ligand for the semaphorin receptor, rather than the viral semaphorin. The naturally occurring ligand would inhibit  
35 migration of tumor cells bearing the VESPR thus inhibiting the movement or metastasis of the transformed tumor cells expressing the VESPR. Such a method may be preferred where it is desired to temporarily arrest the endogenous tumor response and to minimize chances of metastasis, while alternative and

additional cancer therapies, such as chemotherapeutic agents or radiation therapy, are directed to the localized tumor. A similar process allows for treatment of diffuse cancers, such as lymphoma and leukemia.

Alternatively, a useful cancer immunotherapy would include administering a VESPR antagonist or competitive inhibitor, for example, a soluble VESPR, in those cancers in which the cancerous cells overexpress semaphorin ligands that inhibit APC migration. The naturally occurring ligand would inhibit migration of APCs bearing tumor antigen, thus the administration of an antagonist would allow for increased presentation of tumor antigens to T cells, resulting in increased tumor cell immunity as well as an increased targeting of tumor cells by the immune system. Such a cancer immunotherapy would function by competitively inhibiting semaphorin interaction with VESPR, thereby reducing the inhibitory effect of semaphorins on APC migration.

Another indication for antagonizing VESPR might be at the level of antibody production. Antibodies are made after APCs activate  $T_H$  cells, which then provide cytokines that expand B cell populations, causing them to differentiate and to make mature antibodies. As the naturally occurring ligand for VESPR inhibits the migration of APC, the humoral (or antibody response in the presence of the ligand) may be lower than it could be. Thus, antagonizing that inhibition (by, for example, administering a soluble VESPR) might allow a more robust antibody response to a given antigen, or encourage the presentation of rare immunodominant or protective epitopes which would be useful in treating infections or would be useful in an adjuvant-like capacity for bolstering immune response to vaccines.

### 3. Semaphorins and Semaphorin Receptors Can Be Used To Treat Food Intolerances

Another aspect of the invention includes promotion of presentation of food antigens. Normal intake of food exposes the immune system to a wide array of foreign antigens. As the naturally occurring ligand for VESPR diminishes APC cell migration, antagonizing that interaction may lead to increased presentation of food antigens thereby promoting tolerance to the various food antigens. Such antagonism would be indicated in the treatment of individuals exhibiting food allergies or other food intolerances.

### 4. Semaphorins and Semaphorin Receptors Can Be Used To Promote or Suppress Angiogenesis

Mast cells are involved in the formation of new blood vessel formation from endothelium, or angiogenesis. Thus, semaphorins, semaphorin receptors, or agonists or antagonists of the interaction between the two can be used to manipulate angiogenesis in a subject. Such methods or compositions can be used to treat a subject with an immune cell migration-mediated disease or condition characterized in part by deficient vascularization or hypervascularization. Examples of diseases or conditions characterized by deficient vascularization include ischemic tissue or other traumatized tissue, stroke, organ transplantation and the like. Examples of diseases or conditions characterized by hypervascularization include various tumors. Treatment of such conditions can be achieved by, for example, delivering agonists of VESPR, such as an antibody to VESPR or a semaphorin, particularly in a targeted fashion, to help

disrupt the development of new blood vessels needed to feed the tumor. Inhibition of vasculature necessary for tumor growth will assist in inhibition of progression of the tumor, or even regression or destruction of the tumor. Alternatively, delivering a soluble version of VESPR will facilitate the migration of mast cells to areas requiring new vessel formation, such as, for example in patients that have suffered a stroke or have sustained severe tissue damage from organ transplantation, limb reattachment, organ resection or other trauma, ischemia, or the like.

#### D. IDENTIFICATION OF EFFECTORS OF IMMUNE CELL MIGRATION

The interaction between semaphorins and semaphorin receptors can also be used, according to the present invention, to identify additional agents that influence immune cell migration. Such agents may be VESPR ligands, or may be agonists or antagonists of the interaction between VESPR and semaphorins. Examples of such screening assays include a method of screening for a VESPR ligand or other molecule or substance that influences the ability of immune cells to migrate by executing the following steps: (1) contacting a first immune cell comprising a VESPR with a test compound in the presence of a semaphorin; (2) measuring the migration of the first immune cell; and (3) comparing the migration of the first immune cell to migration of a control cell, under comparable conditions in the absence of a test compound. When these steps are followed, the resulting cell migration is observed, with a difference in the motility of the first immune cell relative to the control cell being indicative of an effector of migration of an immune cell. The effector so identified may be either a promoter or a suppressor of immune cell migration.

Alternatively, a VESPR ligand or other molecule or substance that influences immune cell chemotaxis can be identified *via* the following method: (1) contacting an immune cell comprising a VESPR with a test compound in the presence of a known chemokine; (2) measuring the migration of the immune cell; and (3) comparing the migration of the immune cell to migration of a control cell, wherein said control cell is observed under comparable conditions, in the absence of a test compound. When these steps are followed, the resulting cell motility is observed, with a difference in the motility of the immune cell relative to the control cell being indicative of a VESPR ligand or other molecule or substance that functions as an effector of motility of an immune cell. Such screening methods are useful for identifying both promoters and inhibitors of immune cell migration.

Compounds that can be screened in accordance with the invention include but are not limited to peptides (*e.g.*, polypeptides such as proteins, and small peptides), non-peptide organic molecules, and inorganic molecules. A number of compound libraries are commercially available from companies such as Pharmacopeia, Argule, EnzyMed, Sigma, Aldrich, Maybridge, Trega and PanLabs, to name just a few sources. One can also screen libraries of known compounds, including natural products or synthetic chemicals, and biologically active materials for compounds that are effectors of immune cell migration.

### E. ROUTES OF SEMAPHORIN ADMINISTRATION

The presently disclosed compositions and methods may utilize both oral and non-oral administration routes including, for example, by injection *via* the intradermal, subcutaneous, and intravenous routes; by transdermal delivery; by inhalation or buccal delivery, or by ingestion of tablets or capsules. In certain aspects of the invention, compounds may be administered locally to tumors or tumor cells. Local delivery to a solid tumor can be by intratumoral injection, injection circumferential to the tumor, injection into the vascular supply to the tumor, injection into the vasculature or lymphatics to effect infusion of the region containing the tumor, regional perfusion by use of an extracorporeal circuit, or other delivery methods that effect a localized concentration of compound in the tumor or region containing the tumor. Local and regional delivery of compounds to metastasized tumor cells and/or post-resection macroscopic or microscopic residual tumors or tumor cells can be by local injection into the tissue, injection into the vasculature or lymphatics to effect regional infusion, regional perfusion by use of an extracorporeal circuit, or other delivery methods that effect a localized concentration of compound in a region or tissue.

### F. DOSAGES

The optimal daily dose of semaphorin, VESPR or soluble VESPR, or of an agonist or antagonist of one of these, alone or in combination, useful for the purposes of the present invention is determined by methods known in the art. For example, dosages can be determined based on the severity of the disease or condition being treated, the condition of the subject to whom treatment is being given, the desired degree of therapeutic response, and any concomitant therapies being administered to the subject. Ordinarily, however, administration will be such that a serum level of between about 100ng/ml to about 100µg/ml of semaphorin, semaphorin receptor, or agonist or antagonist of either, is achieved. Preferred doses will achieve blood serum levels of between 500ng/ml and 1µg/ml. The dose can be administered in a single or multiple dosage regimen, or may be by a method that allows for a continuous release of relatively small amounts of the active ingredient from a single dosage unit, such as by a transdermal patch or ingested extended release capsule, over the course of one or more days.

To determine when inhibition or retardation of the various target diseases or conditions, or when amelioration, regression or destruction of the targeted diseases or conditions has been achieved, any of the following can be considered: improvement in patient condition or quality of life; increased longevity of life; decreased pain; decreased severity of symptoms of the targeted disease or condition; retardation of abnormal tissue growth or metastases; increase in desired tissue growth, such as in the case of promotion of angiogenesis; increased airway or lung capacity in the case of asthma or other targeted respiratory diseases; increased circulatory capacity in the case of vascular applications of the invention; decreased food intolerance; and the like. Any of these endpoints as well as others may be considered to determine the

effectiveness of the therapy, and may be measured or determined by patient self-evaluation; objective screening; or by diagnostic testing such as by X-ray, CT or PET scanning or the like.

#### G. SEMAPHORIN-CONTAINING FORMULATION COMPONENTS

In addition to a semaphorin, optimal disclosed compositions and methods will vary according to factors such as, for example, the target tissues, target disease, amount of time the formulation will be stored, conditions under which it will be stored and used, including the dosage form of the composition, and the particular patient population to which it may be administered. Adjustments to the formulation by adjusting constituents of the formulations and their relative concentrations, may be made as needed according to the needs of the formulator, administrator or patient. Additional constituent elements of the multi-dose formulations of the present invention may include water, a buffer, a pH-adjusting agent, a surfactant or anti-adsorbant, a wetting agent, a gelling agent, a drying agent, an osmolality adjusting agent, or virtually any other additive or carrier, depending upon the desired dosage form and intended route of administration.

Formulation characteristics that may be modified include, for example, the pH and the osmolality. For example, it may be desired to achieve a formulation that has a pH and osmolality similar to that of human blood or tissues to facilitate the formulation's effectiveness when administered parenterally. Alternatively, to promote the effectiveness of the disclosed compositions when administered via other administration routes, alternative characteristics may be modified.

Buffers are useful in the present invention for, among other purposes, manipulation of the total pH of the pharmaceutical formulation (especially desired for parenteral administration). A variety of buffers known in the art may be used in the present formulations, such as various salts of organic or inorganic acids, bases, or amino acids, and including various forms of citrate, phosphate, tartrate, succinate, adipate, maleate, lactate, acetate, bicarbonate, or carbonate ions. Particularly advantageous buffers for use in parenterally administered forms of the presently disclosed compositions in the present invention include sodium or potassium buffers, particularly sodium phosphate. Depending upon the dosage form and intended route of administration it may alternatively be advantageous to use buffers in different concentrations or to use other additives to adjust the pH of the composition. Useful pH ranges for compositions of the present invention include a pH of about 2.0 to a pH of about 12.0, again, depending upon various factors such as the intended route of administration.

It may also be advantageous to employ surfactants in the presently disclosed formulations. Surfactants or anti-adsorbants that prove useful include polyoxyethylenesorbitans, polyoxyethylenesorbitan monolaurate, polysorbate-20, such as Tween-20<sup>TM</sup>, polysorbate-80, hydroxycellulose, and genapol. By way of example, when any surfactant is employed in the present invention to produce a parenterally administrable composition, it is advantageous to use it in a concentration of about 0.01 to about 0.5 mg/ml.

Additionally, such compositions can be complexed with polyethylene glycol (PEG), metal ions, or incorporated into polymeric compounds such as polyacetic acid, polyglycolic acid, hydrogels, dextran, *etc.*

or incorporated into liposomes, microemulsions, micelles, unilamellar or multilamellar vesicles, erythrocyte ghosts or spheroblasts. Such compositions will influence the physical state, solubility, stability, rate of *in vivo* release and rate of *in vivo* clearance, and are thus chosen according to the intended application.

5 Additional useful additives are readily determined by those of skill in the art, according to particular needs or intended uses of the compositions and formulator. One such particularly useful additional substance is sodium chloride, which is useful for adjusting the osmolality of the formulations to achieve the desired resulting osmolality. Particularly preferred osmolalities for parenteral administration of the disclosed compositions are in the range of about 270 to about 330 mOsm/kg.

## 10 H. PREPARATION OF THE COMPOSITIONS

The formulations described herein may be prepared in water suitably mixed with a surfactant, such as hydroxypropylcellulose or polyoxyethylenesorbitans. In many cases, it will be preferable to include isotonic agents, for example, sugars or sodium chloride as described above. Prolonged absorption of the injectable compositions can be brought about by the use in the compositions of agents delaying absorption, 15 for example, aluminum monostearate or gelatin. Other agents that may be employed include, but are not limited to lecithin, urea, ethylene oxide, propylene oxide, hydroxypropylcellulose, methylcellulose, or polyethylene glycol.

Aqueous compositions (inocula) as described herein may include an effective amount of a desired pharmacologically active agent dissolved or dispersed in a pharmaceutically acceptable aqueous medium. 20 Such compositions are also referred to as inocula. The use of pharmaceutically acceptable carrier media and agents for pharmaceutically active substances is well known in the art. Except insofar as any conventional media or agent is incompatible with the active ingredient, its use in the therapeutic compositions is contemplated. Supplementary active ingredients also can be incorporated into the compositions as described above.

25 A semaphorin used in the present invention may be formulated into a composition in a neutral or salt form. Pharmaceutically acceptable salts include the acid addition salts (formed with the free amino groups of the protein) and those that are formed with inorganic acids such as, for example, hydrochloric or phosphoric acids, or such organic acids as acetic, oxalic, tartaric, mandelic, and the like. Salts formed with the free carboxyl groups can also be derived from inorganic bases such as, for example, sodium, potassium, 30 ammonium, calcium, or ferric hydroxides, and such organic bases as isopropylamine, trimethylamine, histidine, procaine and the like.

The therapeutic compositions of the present invention are advantageously administered in the form of injectable compositions either as liquid solutions or suspensions; solid forms suitable for solution in, or suspension in, liquid prior to injection may also be prepared. Alternatively, the compositions of the present 35 invention may be administered as inhalants in an aerosolized form. Depending upon the needs of the

formulator, administrator, or the subject of the treatment, the presently disclosed compositions may take virtually any form including liquid, suspension, emulsion, solution, oil, mixture, cream, ointment, gel, suppository, semi-solid, aerosol, powder, tablet, or capsule. A typical composition comprises a pharmaceutically acceptable carrier. For instance, the composition may contain 10 mg, 25 mg, 50 mg or up to about 100 mg of human serum albumin per milliliter of phosphate buffered saline.

The formulations as described herein may be contained in a vial, bottle, tube, syringe inhaler or other container for single or multiple administrations. Such containers may be made of glass or a polymer material such as polypropylene, polyethylene, or polyvinylchloride, for example. Preferred containers may include a seal, or other closure system, such as a rubber stopper that may be penetrated by a needle in order to withdraw a single dose and then re-seal upon removal of the needle. All such containers for injectable liquids, lyophilized formulations, reconstituted lyophilized formulations or reconstitutable powders for injection known in the art or for the administration of aerosolized compositions are contemplated for use in the presently disclosed compositions and methods.

## VI. EXAMPLES

The following examples are illustrative only and are not intended to limit the scope of the invention.

### A. EXAMPLE 1: SEMAPHORINS INFLUENCE IMMUNE CELL CHEMOTAXIS AS SHOWN BY ASSAY USING FLUOROBLOK INSERTS

To assay the effect, *in vitro*, of semaphorins in immune cell migration, human monocytes from apparently healthy donors were separated by counter current centrifugation (elutriation) from freshly drawn leukophoresis packs using a Beckman J-6M/E centrifuge (Beckman Instruments Inc.; Palo Alto, CA) and aliquots stored under Liquid Nitrogen. Monocyte samples were thawed rapidly at 37°C and added to 30 ml of ice cold RPMI 1640, 5% FBS (Gibco BRL; Rockville, MD) in a FALCON 50-ml conical tube (Becton Dickinson Labware; Franklin Lakes, NJ) then centrifuged at 1400 rpm, 5 minutes, at room temperature.

Monocytes were resuspended in 30 ml, 37°C Hanks Balanced Salt Solution without phenol red (HBSS w/out red) (Gibco BRL; Rockville, MD), and counted by Trypan Blue (Gibco BRL, Rockville, MD) exclusion to determine viability and cell density. Monocytes were centrifuged as above and resuspended to approximately  $1 \times 10^7$  cells/ml in 37°C HBSS w/out red. Calcein-AM (Molecular Probes; Eugene, OR) was added to 5  $\mu$ M, mixed gently, and incubated 15 minutes in a 37°C water bath, inverting to mix one time during incubation. Monocytes were centrifuged as above, resuspended in 30 mls HBSS w/out red, cell counts determined by Trypan Blue exclusion, and centrifuged again as above to wash.

Monocytes were then again suspended to  $2.86 \times 10^6$  cells/ml in ice cold RPMI 1640 media, 5% FBS, and placed on ice. FALCON HTS 3  $\mu$  Fluoroblok inserts (Becton Dickinson Labware; Franklin Lakes, NJ) were removed from package carefully and placed in FALCON multiwell cell culture insert companion 24 well plates (Becton Dickinson Labware; Franklin Lakes, NJ) using sterile forceps. 350  $\mu$ ls



(approximately  $1 \times 10^6$  cells) of Calcein-AM labeled monocytes were added carefully to each Fluoroblok insert sitting in companion plate, then 900  $\mu$ l of test sample was carefully pipetted into each companion plate well.

Readings were taken every 30 minutes beginning at time zero on a Cytofluor 2 (PerSeptive Biosystems; Framingham MA), excitation 485 nm, emission 530 nm, and gain at 50. Mean and standard deviation were calculated, then results plotted using Deltagraph 4.0 (SPSS; Chicago, IL). Hu MCP-1, Hu MIP1 $\alpha$ , and SDF1 $\alpha$  chemokines were obtained from Pharmingen; San Diego, CA.

Results are shown in Figure 1. These data show that the semaphorin A39R inhibits both spontaneous migration of monocytes, as well as monocyte migration towards the monocyte-attracting chemokine MCP-1 (as shown in lines  $\blacktriangle$ - and  $\blacklozenge$ -). These data also show that VESPR mediates this inhibitory effect of the semaphorin. M460 is a blocking mAb directed against VESPR. According to these results, M460 partially reverses the inhibitory effects of A39R (see line  $\Delta$ -). Further confirming the role of VESPR is the data showing that M461, a non-blocking mAb against VESPR and having the same isotype as M460, does not influence the inhibitory effect of the semaphorin (see line  $\circ$ -).

**B. EXAMPLE 2: SEMAPHORINS INFLUENCE IMMUNE CELL CHEMOTAXIS AS SHOWN BY UNDER AGAROSE MIGRATION ASSAY**

RPMI 1640 was made up to a 2x concentration with FBS (Gibco BRL; Rockville, MD) added to 10% of the final volume, and placed at 55 °C for 15 minutes. Autoclaved 2% Seakem Agarose (FMC Bioproducts; Rockland, Maine) in water was heated until completely liquified by microwaving then placed at 55°C for 15 minutes. Agarose and media were mixed carefully 1:1 to avoid excess air bubbles in a FALCON 50-ml conical tube (Becton Dickinson Labware; Franklin Lakes, NJ) sitting in a beaker of 55°C water. 10 mls of agarose media mix was added to FALCON 10-cm petri dishes (Becton Dickinson Labware; Franklin Lakes, NJ) placed on a level surface and allowed to solidify for 5 minutes.

Plates were then transferred to a 4°C cooler to further harden for 10 minutes. Three wells in a straight line were cut into the hardened agarose with a 3/32-inch steel hole punch approximately 2.4 mm apart, by placing a template below the dish. Three sets of wells were cut per plate in an equidistant radial pattern. Agarose plugs were carefully removed from the wells by aspiration. Human monocytes from apparently healthy donors were separated by counter current centrifugation (elutriation) from freshly drawn leukophoresis packs using a Beckman J-6M/E centrifuge (Beckman Instruments, Inc.; Palo Alto, CA) and aliquots stored under Liquid Nitrogen.

Monocyte samples were thawed rapidly at 37°C and added to 30 ml of ice cold RPMI 1640, 5% FBS in a FALCON 50-ml conical tube then centrifuged at 1400 rpm, 5 minutes, at room temperature. Monocytes were resuspended in 10-mls of above media, placed on ice, and cell count determined by Trypan Blue (Gibco BRL; Rockville, MD) exclusion. Centrifuge monocytes as above and resuspended to  $2.0 \times 10^8$  cells/ml, keeping cells on ice. Test samples made up in above media in FALCON 15-ML conical tubes and placed on ice.

5  $\mu$ l of cell suspension were added to center well, 5  $\mu$ l of test sample were added to outer well, and 5  $\mu$ l of media were added to inner well for each of the three sets of wells per plate. Plates were incubated at 37°C, 5% CO<sub>2</sub>, 100% methanol for either 30 minutes, or overnight at 4°C. Methanol was aspirated from plate, and 5 ml 4% formalin (Sigma;) added for 30 minutes at room temperature to fix cells. Agarose layer was then carefully removed from plate, and plates stained with crystal violet(;) for 1 minute, crystal violet was removed, plates washed in water and allowed to dry.

Results are shown in Figure 2. These data show the results of the under agarose assays, indicating that migration of immune cells, specifically APCs, in the presence of semaphorin, is inhibited. The bottom frame shows diffuse cells in assay lacking chemokines; the middle frame shows that, in the presence of A39R and MCP1, the cells do not migrate toward the chemo-attractant MCP1, while in the top frame, cells are clearly drawn towards MCP1 in the absence of the semaphorin A39R.

**C. Example 3: Semaphorins Influence Immune Cell Chemotaxis and Do Not Induce Cell Death As Shown by Alamar Blue Proliferation Assay**

To confirm that the VESPR-mediated semaphorin effect on the monocytes was in fact inhibitory, and not lethal, the following cell proliferation assay was performed:

Cells were prepared for assay by harvesting as appropriate into FALCON 15 ml or 50 ml conical tubes (Becton Dickinson Labware; Franklin Lakes, NJ), then centrifuging at 1200-1500 rpm, room temperature for 5 minutes. Cells were resuspended in media minus growth factor, then centrifuged again and resuspended at density for assay. One ml of cell suspension was added per well of a Falcon 24 well non-tissue culture treated plate (Becton Dickinson Labware; Franklin Lakes, NJ). Test samples were added to cells plus samples at 37°C, 100% humidity, 5% CO<sub>2</sub> ranging from 18-72 hours, to 10% of final volume. Readings of Alamar Blue processing were then taken at various time points post addition with a Cytofluor 2 fluorescent plate reader (PerSeptive Biosystems; Framingham, MA) excitation 530 nm, emission 590 nm, and gain at 40. Results were graphed using Deltagraph 4.0 (SPSS Inc.; Chicago, IL). Viability of cell samples over the various incubation periods was tested by trypan blue exclusion indicating A39R had little or no effect on cell viability.

Human monocytes purified by elutriation from freshly drawn leukaphoresis packs. TF-1, human bone marrow erythroleukemia cell line were tested in this assay.

Data from the cell proliferation assay are shown in Figure 3. These data show that semaphorins, or semaphorin-receptor complexes influence immune cell motility, but are not lethal to the cells. An increase in fluorescence over time shows that the cells are viable. Cells exposed to A39R remain viable (see lines - •-, -□-, -○-, and -◇-). These data confirm that, in cases such as where monocyte migration is inhibited, this immobilization is not the result of cell death.

**D. EXAMPLE 4: SEMAPHORINS INFLUENCE LANGERHANS CELL MIGRATION *IN VIVO***

*In vivo* analysis of the effects of A39R on Langerhans cell migration was performed, to confirm semaphorin effect on cell migration *in vivo*. To begin, mice were anesthetized with 0.3-ml of Avertin(;)

per mouse by intraperitoneal injection. The forearms of each mouse were then shaved, and various amounts of protein or Saline (Baxter Healthcare Corp.; Deerfield, IL) in a 10 $\mu$ l volume were injected by subcutaneous administration using a 1 ml Hamilton syringe (Hamilton Company; Reno, NV) in the front of each forearm.

5           10-20 $\mu$ l of either a 1% w/v Fluorescein Iso-Thio-Cyanate (FITC) (Sigma; St. Louis, MO) solution made up in a 1:1 Acetone: Dibutylphthalate (Sigma; St. Louis, MO), or 1:1 Acetone: Dibutylphthalate were then "painted" over the injection site in a drop-wise fashion using a P20 pippetteman (Rainin Instrument Company Inc.; Woburn, MA). The mice were allowed to rest 24 hours and then sacrificed by CO<sub>2</sub> asphyxiation.

10           The axillary and brachial lymph nodes from each animal were taken and placed in 20 mls of RPMI 1640 (Gibco BRL; Rockville, MD), 5% FBS (Gibco BRL; Rockville, MD) in a FALCON 50 ml conical tube (Becton Dickinson Labware; Franklin Lakes, NJ) sitting on ice. The conicals were then centrifuged at 1200 rpm for 5 minutes at room temperature, and the supernatant was removed by aspiration. The lymph nodes were resuspended in 10 mls of 200 units/ml Collagenase type 3 (Worthington Biochemical Corp.;  
15 Freehold, NJ) made up in Hanks Balanced Salt Solution with calcium and magnesium (Gibco BRL; Rockville, MD), containing 1 g NaCl, pH adjusted to 7.4 with NaOH. Suspensions were then added to FALCON petri dishes (Becton Dickinson Labware; Franklin Lakes, NJ).

            Lymph nodes were then gently teased apart with sterile forceps, and incubated at 37°C, 5% CO<sub>2</sub>, 100% humidity for 30 minutes. Each lymph node suspensions were removed from dish and filtered  
20 through a FALCON nylon cell strainer (Becton Dickinson Labware; Franklin Lakes, NJ) sitting in a FALCON 50 ml conical tube on ice. The black rubber end of a plunger from a 5-ml syringe (Becton Dickinson Labware; Franklin Lakes, NJ) was used to mash any large chunks sitting in cell strainer. 10 ml of Hanks Balanced Salt Solution with calcium and magnesium (Gibco BRL; Rockville, MD), containing 1 g NaCl, and pH adjusted to 7.4 with NaOH was added to each dish to wash. Dishes were gently scraped  
25 with a COSTAR cell scraper (Corning Inc.; Corning, NY), wash was removed from each plate and added to corresponding conical tube through cell strainer. Lymph node suspension were centrifuged at 1200 rpm, for 5 minutes at room temperature, resuspended in 10 ml of Hanks Balanced Salt Solution without calcium and magnesium (Gibco BRL; Rockville, MD), containing 10 mM EDTA, pH adjusted to 7.4 with HCL, and centrifuged again.

30           Nycodenz solution stock was made up by adding 15.275 g Nycodenz powder (Gibco BRL; Rockville, MD) to 50 ml, 37°C Baxter water (Baxter Healthcare Corp.; Deerfield, IL), then filtered through a Corning 0.45 $\mu$  cellulose acetate low protein binding membrane (Corning Inc.; Corning, NY), stock stored at 4°C in the dark.

            Nycodenz buffer was made up by adding 9g NaCl, 0.6055 g Tris, 0.22368g KCl, 0.11167g EDTA,  
35 to 1 L of Baxter water, pH adjusted to 7.4, and volume brought up to 1.120L with Baxter water. Nycodenz working solution was made up by adding 46-ml of Nycodenz solution stock to 54-ml Nycodenz buffer.

Cell pellets were resuspended in 5 ml of Nycodenz working solution and removed to FALCON 15-ml conical tubes (Becton Dickinson Labware: Franklin Lakes, NJ). 3ml of Hanks Balanced Salt Solution without calcium and magnesium (Gibco BRL: Rockville, MD), containing 10 mM EDTA, pH adjusted to 7.4 with HCL, were then carefully overlaid on the Nycodenz working solution cell suspensions, then  
5 centrifuged at 2700 rpm for 20 minutes at 4°C with the brake off. The interfaces from each resulting gradient were then carefully removed to a FALCON 15ml conical tube by pipetting, and centrifuged at 1200 rpm for 5 minutes at room temperature. Pellets were resuspended in 5 ml of ice cold RPMI 1640, 5% FBS and placed on ice.

Following isolation, cells were stained with a conjugated (phycoerythrin) anti MHC class II stain,  
10 and analyzed on a flow cytometer (Becton-Dickinson). Cells that showed double positive staining (*i.e.* positive for FITC and positive for MHC class II) were presumed to be Langerhans cells. Under these conditions, a two fold reduction in the amount of migrating Langerhans cells in animals administered A39R compared to those administered control protein was observed. Specifically, as shown in Figure 4, Langerhans cell migration to regional lymph nodes (upper right quadrant) in A39R-treated animals and  
15 control animals indicated that, *in vivo*, APC migration to regional lymph nodes was inhibited by the semaphorin (9.19% versus 6.21%).

#### E. EXAMPLE 5: VESPR IS EXPRESSED AT HIGH LEVELS IN MAST CELLS

Immunohistochemistry (IHC) and standard histological examination of rodent tissues was used to detect the semaphorin binding protein VESPR. Mast cells expressing VESPR bound biotinylated A39R  
20 throughout the tissues examined, including spleen, lymph node, sinus, retina, skin and lung. The finding that mast cells express significant amounts of VESPR indicates that interaction with the VESPR ligand, in other words with semaphorins or VESPR agonists or antagonists, will affect the migration of mast cells.

#### REFERENCES

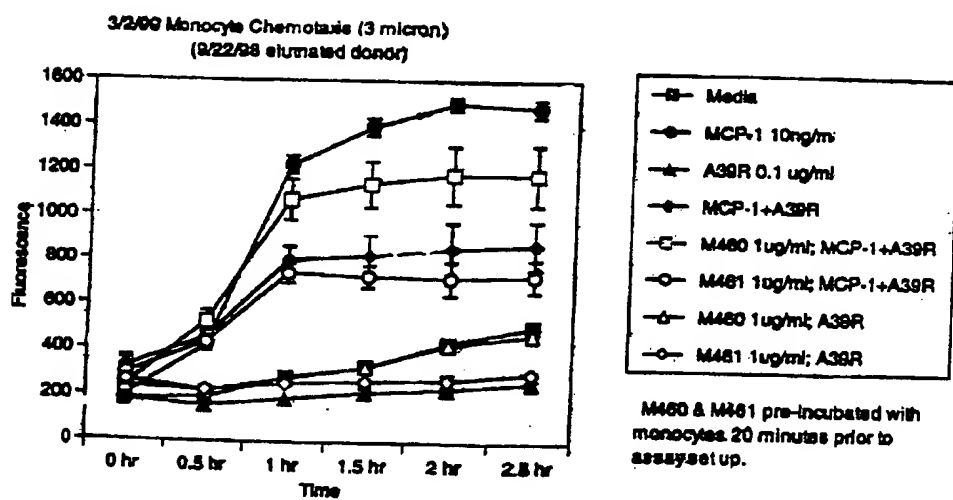
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**CLAIMS**

1. Use of a semaphorin or an agonistic antibody to a VESPR in the manufacture of a medicament for neoplastic disease; auto-immune or hypersensitivity disorders characterized in part by an inflammatory response; promotion or suppression of angiogenesis; or food intolerance.
- 5 2. Use of a VESPR in the manufacture of a medicament for neoplastic disease; auto-immune or hypersensitivity disorders characterized in part by an inflammatory response; promotion or suppression of angiogenesis; or food intolerance.

FIG. 1



**FIG. 2**

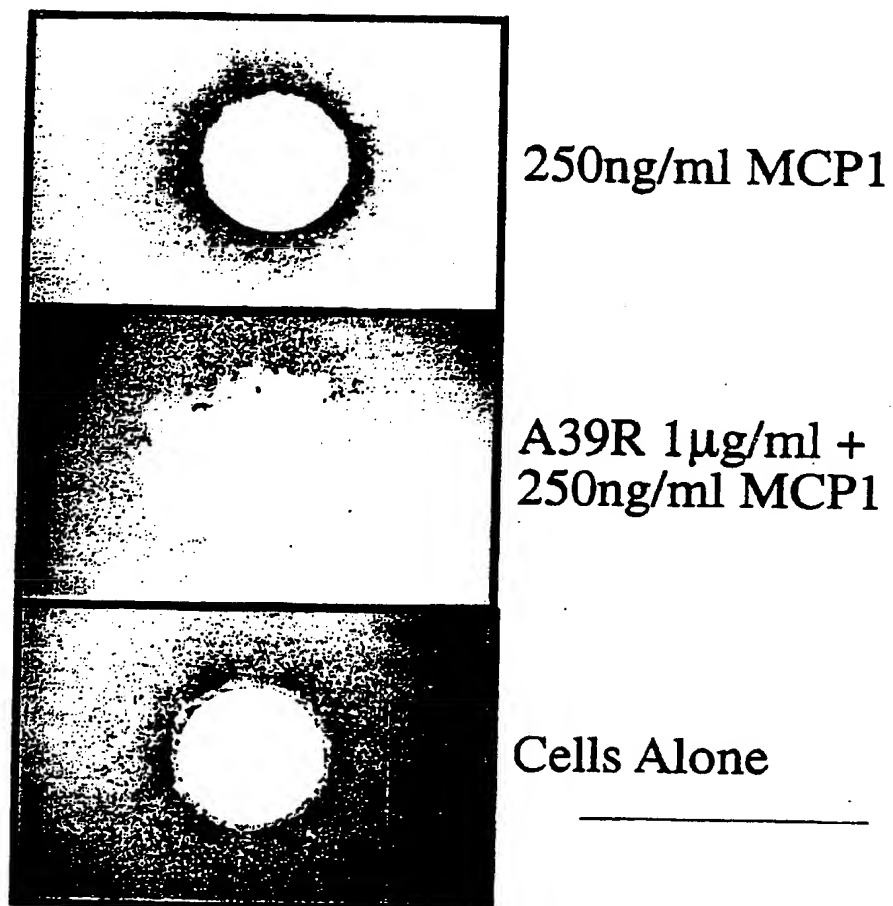




FIG. 3

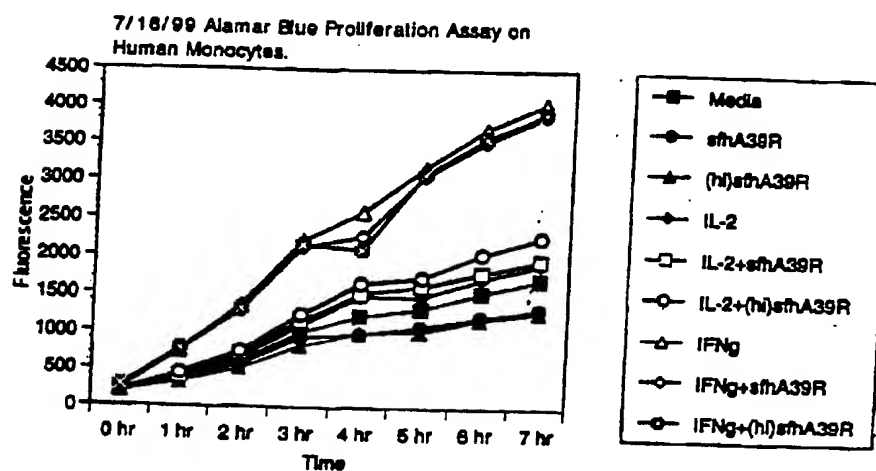
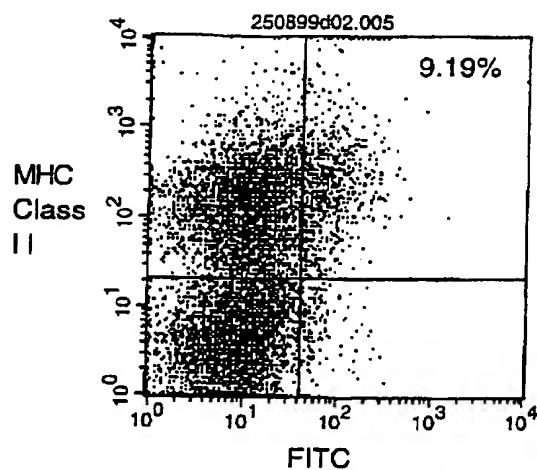


FIG. 4

A.

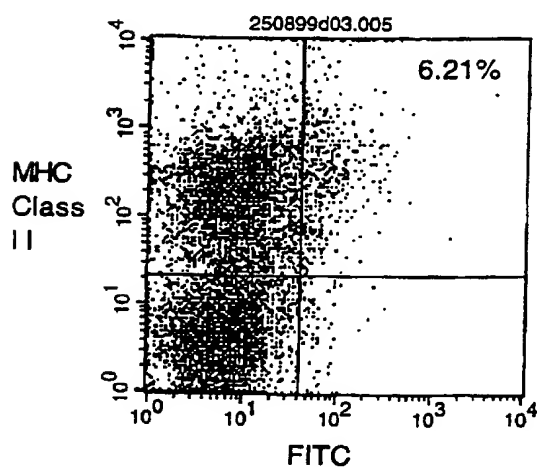


Control Treated Animal

## Quadrant Statistics

Quad	% Total	X Mean	Y Mean
UL	42.66	13.03	262.17
UR	9.19	119.74	751.15
LL	46.14	10.65	5.52
LR	2.01	88.66	8.14

B.



A39R Treated Animal

## Quadrant Statistics

Quad	% Total	X Mean	Y Mean
UL	46.07	10.60	341.60
UR	6.21	125.31	1336.38
LL	46.73	7.93	5.44
LR	1.00	85.22	8.05

## INFORMATION FOR SEQ ID NO:1:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 4707 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: double
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

## (ix) FEATURE:

- (A) NAME/KEY: CDS
- (B) LOCATION: 1..4707

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

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Ala Pro Leu Pro Leu Leu Ala Tyr Leu Leu Ala Leu Ala Ala Pro Gly	
20 25 30	
CGG GGC GCG GAC GAG CCC GTG TGG CGG TCG GAG CAA GCC ATC GGA GCC	144
Arg Gly Ala Asp Glu Pro Val Trp Arg Ser Glu Gln Ala Ile Gly Ala	
35 40 45	
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Ser Asp Tyr Glu Arg Asn Gln Glu Gln Cys Pro Val Ala Val Glu Lys		
625	630	640
ACA TCA GGA GGA GGA AGA CCC AAG GAG AAC AAG GGG AAC AGA ACC AAC		1968
Thr Ser Gly Gly Gly Arg Pro Lys Glu Asn Lys Gly Asn Arg Thr Asn		
645	650	655
CAG GCT TTA CAG GTC TTC TAC ATT AAG TCC ATT GAG CCA CAG AAA GTA		2016
Gln Ala Leu Gln Val Phe Tyr Ile Lys Ser Ile Glu Pro Gln Lys Val		
660	665	670
TCG ACA TTA GGG AAA AGC AAC GTG ATA GTA ACG GGA GCA AAC TTT ACC		2064
Ser Thr Leu Gly Lys Ser Asn Val Ile Val Thr Gly Ala Asn Phe Thr		
675	680	685
CGG GCA TCG AAC ATC ACA ATG ATC CTG AAA GGA ACC AGT ACC TGT GAT		2112
Arg Ala Ser Asn Ile Thr Met Ile Leu Lys Gly Thr Ser Thr Cys Asp		
690	695	700
AAG GAT GTG ATA CAG GTT AGC CAT GTG CTA AAT GAC ACC CAC ATG AAA		2160
Lys Asp Val Ile Gln Val Ser His Val Leu Asn Asp Thr His Met Lys		
705	710	720
TTC TCT CTT CCA TCA AGC CGG AAA GAA ATG AAG GAT GTG TGT ATC CAG		2208
Phe Ser Leu Pro Ser Ser Arg Lys Glu Met Lys Asp Val Cys Ile Gln		
725	730	735
TTT GAT GGT GGG AAC TGC TCT TCT GTG GGA TCC TTA TCC TAC ATT GCT		2256
Phe Asp Gly Gly Asn Cys Ser Ser Val Gly Ser Leu Ser Tyr Ile Ala		
740	745	750
CTG CCA CAT TGT TCC CTT ATA TTT CCT GCT ACC ACC TGG ATC AGT GGT		2304
Leu Pro His Cys Ser Leu Ile Phe Pro Ala Thr Thr Trp Ile Ser Gly		

755	760	765	
GGT CAA AAT ATA ACC ATG ATG GGC AGA AAT TTT GAT GTA ATT GAC AAC Gly Gln Asn Ile Thr Met Met Gly Arg Asn Phe Asp Val Ile Asp Asn 770 775 780			2352
TTA ATC ATT TCA CAT GAA TTA AAA GGA AAC ATA AAT GTC TCT GAA TAT Leu Ile Ile Ser His Glu Leu Lys Gly Asn Ile Asn Val Ser Glu Tyr 785 790 795 800			2400
TGT GTG GCG ACT TAC TGC GGG TTT TTA GCC CCC AGT TTA AAG AGT TCA Cys Val Ala Thr Tyr Cys Gly Phe Leu Ala Pro Ser Leu Lys Ser Ser 805 810 815			2448
AAA GTG CGC ACG AAT GTC ACT GTG AAG CTG AGA GTA CAA GAC ACC TAC Lys Val Arg Thr Asn Val Thr Val Lys Leu Arg Val Gln Asp Thr Tyr 820 825 830			2496
TTG GAT TGT GGA ACC CTG CAG TAT CGG GAG GAC CCC AGA TTC ACG GGG Leu Asp Cys Gly Thr Leu Gln Tyr Arg Glu Asp Pro Arg Phe Thr Gly 835 840 845			2544
TAT CGG GTG GAA TCC GAG GTG GAC ACA GAA CTG GAA GTG AAA ATT CAA Tyr Arg Val Glu Ser Glu Val Asp Thr Glu Leu Glu Val Lys Ile Gln 850 855 860			2592
AAA GAA AAT GAC AAC TTC AAT ATT TCC AAA AAA GAC ATT GAA ATT ACT Lys Glu Asn Asp Asn Phe Asn Ile Ser Lys Lys Asp Ile Glu Ile Thr 865 870 875 880			2640
CTC TTC CAT GGG GAA AAT GGG CAA TTA AAT TGC AGT TTT GAA AAT ATT Leu Phe His Gly Glu Asn Gly Gln Leu Asn Cys Ser Phe Glu Asn Ile 885 890 895			2688
ACT AGA AAT CAA GAT CTT ACC ACC ATC CTT TGC AAA ATT AAA GGC ATC Thr Arg Asn Gln Asp Leu Thr Thr Ile Leu Cys Lys Ile Lys Gly Ile 900 905 910			2736
AAG ACT GCA AGC ACC ATT GCC AAC TCT TCT AAG AAA GTT CGG GTC AAG Lys Thr Ala Ser Thr Ile Ala Asn Ser Ser Lys Lys Val Arg Val Lys 915 920 925			2784
CTG GGA AAC CTG GAG CTC TAC GTC GAG CAG GAG TCA GTT CCT TCC ACA Leu Gly Asn Leu Glu Leu Tyr Val Glu Gln Glu Ser Val Pro Ser Thr 930 935 940			2832
TGG TAT TTT CTG ATT GTG CTC CCT GTC TTG CTA GTG ATT GTC ATT TTT Trp Tyr Phe Leu Ile Val Leu Pro Val Leu Leu Val Ile Val Ile Phe 945 950 955 960			2880
GCG GCC GTG GGG GTG ACC AGG CAC AAA TCG AAG GAG CTG AGT CGC AAA Ala Ala Val Gly Val Thr Arg His Lys Ser Lys Glu Leu Ser Arg Lys 965 970 975			2928

CAG AGT CAA CAA CTA GAA TTG CTG GAA AGC GAG CTC CGG AAA GAG ATA Gln Ser Gln Gln Leu Glu Leu Leu Glu Ser Glu Leu Arg Lys Glu Ile 980 985 990	2976
CGT GAC GGC TTT GCT GAG CTG CAG ATG GAT AAA TTG GAT GTG GTT GAT Arg Asp Gly Phe Ala Glu Leu Gln Met Asp Lys Leu Asp Val Val Asp 995 1000 1005	3024
AGT TTT GGA ACT GTT CCC TTC CTT GAC TAC AAA CAT TTT GCT CTG AGA Ser Phe Gly Thr Val Pro Phe Leu Asp Tyr Lys His Phe Ala Leu Arg 1010 1015 1020	3072
ACT TTC TTC CCT GAG TCA GGT GGC TTC ACC CAC ATC TTC ACT GAA GAT Thr Phe Phe Pro Glu Ser Gly Gly Phe Thr His Ile Phe Thr Glu Asp 1025 1030 1035 1040	3120
ATG CAT AAC AGA GAC GCC AAC GAC AAG AAT GAA AGT CTC ACA GCT TTG Met His Asn Arg Asp Ala Asn Asp Lys Asn Glu Ser Leu Thr Ala Leu 1045 1050 1055	3168
GAT GCC CTA ATC TGT AAT AAA AGC TTT CTT GTT ACT GTC ATC CAC ACC Asp Ala Leu Ile Cys Asn Lys Ser Phe Leu Val Thr Val Ile His Thr 1060 1065 1070	3216
CTT GAA AAG CAG AAG AAC TTT TCT GTG AAG GAC AGG TGT CTG TTT GCC Leu Glu Lys Gln Lys Asn Phe Ser Val Lys Asp Arg Cys Leu Phe Ala 1075 1080 1085	3264
TCC TTC CTA ACC ATT GCA CTG CAA ACC AAG CTG GTC TAC CTG ACC AGC Ser Phe Leu Thr Ile Ala Leu Gln Thr Lys Leu Val Tyr Leu Thr Ser 1090 1095 1100	3312
ATC CTA GAG GTG CTG ACC AGG GAC TTG ATG GAA CAG TGT ACT AAC ATG Ile Leu Glu Val Leu Thr Arg Asp Leu Met Glu Gln Cys Ser Asn Met 1105 1110 1115 1120	3360
CAG CCG AAA CTC ATG CTG AGA CGC ACG GAG TCC GTC GTC GAA AAA CTC Gln Pro Lys Leu Met Leu Arg Arg Thr Glu Ser Val Val Glu Lys Leu 1125 1130 1135	3408
CTC ACA AAC TGG ATG TCC GTC TGC CTT TCT GGA TTT CTC CGG GAG ACT Leu Thr Asn Trp Met Ser Val Cys Leu Ser Gly Phe Leu Arg Glu Thr 1140 1145 1150	3456
GTC GGA GAG CCC TTC TAT TTG CTG GTG ACG ACT CTG AAC CAG AAA ATT Val Gly Glu Pro Phe Tyr Leu Leu Val Thr Thr Leu Asn Gln Lys Ile 1155 1160 1165	3504
AAC AAG GGT CCC GTG GAT GTA ATC ACT TGC AAA GCC CTG TAC ACA CTT Asn Lys Gly Pro Val Asp Val Ile Thr Cys Lys Ala Leu Tyr Thr Leu 1170 1175 1180	3552



AAT GAA GAC TGG CTG TTG TGG CAG GTT CCG GAA TTC AGT ACT GTG GCA Asn Glu Asp Trp Leu Trp Gln Val Pro Glu Phe Ser Thr Val Ala 1185 1190 1195 1200	3600
TTA AAC GTC GTC TTT GAA AAA ATC CCG GAA AAC GAG AGT GCA GAT GTC Leu Asn Val Val Phe Glu Lys Ile Pro Glu Asn Glu Ser Ala Asp Val 1205 1210 1215	3648
TGT CGG AAT ATT TCA GTC AAT GTT CTC GAC TGT GAC ACC ATT GGC CAA Cys Arg Asn Ile Ser Val Asn Val Leu Asp Cys Asp Thr Ile Gly Gln 1220 1225 1230	3696
GCC AAA GAA AAG ATT TTC CAA GCA TTC TTA AGC AAA AAT GGC TCT CCT Ala Lys Glu Lys Ile Phe Gln Ala Phe Leu Ser Lys Asn Gly Ser Pro 1235 1240 1245	3744
TAT GGA CTT CAG CTT AAT GAA ATT GGT CTT GAG CTT CAA ATG GGC ACA Tyr Gly Leu Gln Leu Asn Glu Ile Gly Leu Glu Leu Gln Met Gly Thr 1250 1255 1260	3792
CGA CAG AAA GAA CTT CTG GAC ATC GAC AGT TCC TCC GTG ATT CTT GAA Arg Gln Lys Glu Leu Leu Asp Ile Asp Ser Ser Ser Val Ile Leu Glu 1265 1270 1275 1280	3840
GAT GGA ATC ACC AAG CTA AAC ACC ATT GGC CAC TAT GAG ATA TCA AAT Asp Gly Ile Thr Lys Leu Asn Thr Ile Gly His Tyr Glu Ile Ser Asn 1285 1290 1295	3888
GGA TCC ACT ATA AAA GTC TTT AAG AAG ATA GCA AAT TTT ACT TCA GAT Gly Ser Thr Ile Lys Val Phe Lys Lys Ile Ala Asn Phe Thr Ser Asp 1300 1305 1310	3936
GTG GAG TAC TCG GAT GAC CAC TGC CAT TTG ATT TTA CCA GAT TCG GAA Val Glu Tyr Ser Asp Asp His Cys His Leu Ile Leu Pro Asp Ser Glu 1315 1320 1325	3984
GCA TTC CAA GAT GTG CAA GGA AAG AGA CAT CGA GGG AAG CAC AAG TTC Ala Phe Gln Asp Val Gln Gly Lys Arg His Arg Gly Lys His Lys Phe 1330 1335 1340	4032
AAA GTA AAA GAA ATG TAT CTG ACA AAG CTG CTG TCG ACC AAG GTG GCA Lys Val Lys Glu Met Tyr Leu Thr Lys Leu Leu Ser Thr Lys Val Ala 1345 1350 1355 1360	4080
ATT CAT TCT GTG CTT GAA AAA CTT TTT AGA AGC ATT TGG AGT TTA CCC Ile His Ser Val Leu Glu Lys Leu Phe Arg Ser Ile Trp Ser Leu Pro 1365 1370 1375	4128
AAC AGC AGA GCT CCA TTT GCT ATA AAA TAC TTT TTT GAC TTT TTG GAC Asn Ser Arg Ala Pro Phe Ala Ile Lys Tyr Phe Phe Asp Phe Leu Asp 1380 1385 1390	4176
GCC CAG GCT GAA AAC AAA AAA ATC ACA GAT CCT GAC GTC GTA CAT ATT	4224

Ala Gln Ala Glu Asn Lys Lys Ile Thr Asp Pro Asp Val Val His Ile	
1395 1400 1405	
TGG AAA ACA AAC AGC CTT CCT CTT CGC TTC TGG GTA AAC ATC CTG AAG	4272
Trp Lys Thr Asn Ser Leu Pro Leu Arg Phe Trp Val Asn Ile Leu Lys	
1410 1415 1420	
AAC CCT CAG TTT GTC TTT GAC ATT AAG AAG ACA CCA CAT ATA GAC GGC	4320
Asn Pro Gln Phe Val Phe Asp Ile Lys Lys Thr Pro His Ile Asp Gly	
1425 1430 1435 1440	
TGT TTG TCA GTG ATT GCC CAG GCA TTC ATG GAT GCA TTT TCT CTC ACA	4368
Cys Leu Ser Val Ile Ala Gln Ala Phe Met Asp Ala Phe Ser Leu Thr	
1445 1450 1455	
GAG CAG CAA CTA GGG AAG GAA GCA CCA ACT AAT AAG CTT CTC TAT GCC	4416
Glu Gln Gln Leu Gly Lys Glu Ala Pro Thr Asn Lys Leu Leu Tyr Ala	
1460 1465 1470	
AAG GAT ATC CCA ACC TAC AAA GAA GAA GTA AAA TCT TAT TAC AAA GCA	4464
Lys Asp Ile Pro Thr Tyr Lys Glu Glu Val Lys Ser Tyr Tyr Lys Ala	
1475 1480 1485	
ATC AGG GAT TTG CCT CCA TTG TCA TCC TCA GAA ATG GAA GAA TTT TTA	4512
Ile Arg Asp Leu Pro Pro Leu Ser Ser Ser Glu Met Glu Glu Phe Leu	
1490 1495 1500	
ACT CAG GAA TCT AAG AAA CAT GAA AAT GAA TTT AAT GAA GAA GTG GCC	4560
Thr Gln Glu Ser Lys Lys His Glu Asn Glu Phe Asn Glu Glu Val Ala	
1505 1510 1515 1520	
TTG ACA GAA ATT TAC AAA TAC ATC GTA AAA TAT TTT GAT GAG ATT CTA	4608
Leu Thr Glu Ile Tyr Lys Tyr Ile Val Lys Tyr Phe Asp Glu Ile Leu	
1525 1530 1535	
AAT AAA CTA GAA AGA GAA CGA GGG CTG GAA GAA GCT CAG AAA CAA CTC	4656
Asn Lys Leu Glu Arg Glu Arg Gly Leu Glu Glu Ala Gln Lys Gln Leu	
1540 1545 1550	
TTG CAT GTA AAA GTC TTA TTT GAT GAA AAG AAG AAA TGC AAG TGG ATG	4704
Leu His Val Lys Val Leu Phe Asp Glu Lys Lys Lys Cys Lys Trp Met	
1555 1560 1565	
TAA	4707
*	

INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1569 amino acids
- (B) TYPE: amino acid
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

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Met Glu Val Ser Arg Arg Lys Ala Pro Pro Arg Pro Pro Arg Pro Ala
 1           5           10          15
Ala Pro Leu Pro Leu Leu Ala Tyr Leu Leu Ala Leu Ala Ala Pro Gly
          20          25          30
Arg Gly Ala Asp Glu Pro Val Trp Arg Ser Glu Gln Ala Ile Gly Ala
      35          40          45
Ile Ala Ala Ser Gln Glu Asp Gly Val Phe Val Ala Ser Gly Ser Cys
      50          55          60
Leu Asp Gln Leu Asp Tyr Ser Leu Glu His Ser Leu Ser Arg Leu Tyr
      65          70          75          80
Arg Asp Gln Ala Gly Asn Cys Thr Glu Pro Val Ser Leu Ala Pro Pro
          85          90          95
Ala Arg Pro Arg Pro Gly Ser Ser Phe Ser Lys Leu Leu Leu Pro Tyr
      100          105          110
Arg Glu Gly Ala Ala Gly Leu Gly Gly Leu Leu Leu Thr Gly Trp Thr
      115          120          125
Phe Asp Arg Gly Ala Cys Glu Val Arg Pro Leu Gly Asn Leu Ser Arg
      130          135          140
Asn Ser Leu Arg Asn Gly Thr Glu Val Val Ser Cys His Pro Gln Gly
      145          150          155          160
Ser Thr Ala Gly Val Val Tyr Arg Ala Gly Arg Asn Asn Arg Trp Tyr
          165          170          175
Leu Ala Val Ala Ala Thr Tyr Val Leu Pro Glu Pro Glu Thr Ala Ser
          180          185          190
Arg Cys Asn Pro Ala Ala Ser Asp His Asp Thr Ala Ile Ala Leu Lys
          195          200          205
Asp Thr Glu Gly Arg Ser Leu Ala Thr Gln Glu Leu Gly Arg Leu Lys
      210          215          220
Leu Cys Glu Gly Ala Gly Ser Leu His Phe Val Asp Ala Phe Leu Trp
      225          230          235          240
Asn Gly Ser Ile Tyr Phe Pro Tyr Tyr Pro Tyr Asn Tyr Thr Ser Gly
          245          250          255

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 260 265 270  
 Val Leu Phe Gln Gly Gln Ala Ser Leu Asp Cys Gly His Gly His Pro  
 275 280 285  
 Asp Gly Arg Arg Leu Leu Leu Ser Ser Ser Leu Val Glu Ala Leu Asp  
 290 295 300  
 Val Trp Ala Gly Val Phe Ser Ala Ala Ala Gly Glu Gly Gln Glu Arg  
 305 310 315 320  
 Arg Ser Pro Thr Thr Thr Ala Leu Cys Leu Phe Arg Met Ser Glu Ile  
 325 330 335  
 Gln Ala Arg Ala Lys Arg Val Ser Trp Asp Phe Lys Thr Ala Glu Ser  
 340 345 350  
 His Cys Lys Glu Gly Asp Gln Pro Glu Arg Val Gln Pro Ile Ala Ser  
 355 360 365  
 Ser Thr Leu Ile His Ser Asp Leu Thr Ser Val Tyr Gly Thr Val Val  
 370 375 380  
 Met Asn Arg Thr Val Leu Phe Leu Gly Thr Gly Asp Gly Gln Leu Leu  
 385 390 395 400  
 Lys Val Ile Leu Gly Glu Asn Leu Thr Ser Asn Cys Pro Glu Val Ile  
 405 410 415  
 Tyr Glu Ile Lys Glu Glu Thr Pro Val Phe Tyr Lys Leu Val Pro Asp  
 420 425 430  
 Pro Val Lys Asn Ile Tyr Ile Tyr Leu Thr Ala Gly Lys Glu Val Arg  
 435 440 445  
 Arg Ile Arg Val Ala Asn Cys Asn Lys His Lys Ser Cys Ser Glu Cys  
 450 455 460  
 Leu Thr Ala Thr Asp Pro His Cys Gly Trp Cys His Ser Leu Gln Arg  
 465 470 475 480  
 Cys Thr Phe Gln Gly Asp Cys Val His Ser Glu Asn Leu Glu Asn Trp  
 485 490 495  
 Leu Asp Ile Ser Ser Gly Ala Lys Lys Cys Pro Lys Ile Gln Ile Ile  
 500 505 510  
 Arg Ser Ser Lys Glu Lys Thr Thr Val Thr Met Val Gly Ser Phe Ser  
 515 520 525  
 Pro Arg His Ser Lys Cys Met Val Lys Asn Val Asp Ser Ser Arg Glu  
 530 535 540

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 545 550 555 560  
 Pro Thr Arg Ala Thr Tyr Lys Asp Val Ser Val Val Asn Val Met Phe  
 565 570 575  
 Ser Phe Gly Ser Trp Asn Leu Ser Asp Arg Phe Asn Phe Thr Asn Cys  
 580 585 590  
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 595 600 605  
 Cys Lys Ser Ala Arg Arg Cys Ile His Pro Phe Thr Ala Cys Asp Pro  
 610 615 620  
 Ser Asp Tyr Glu Arg Asn Gln Glu Gln Cys Pro Val Ala Val Glu Lys  
 625 630 635 640  
 Thr Ser Gly Gly Gly Arg Pro Lys Glu Asn Lys Gly Asn Arg Thr Asn  
 645 650 655  
 Gln Ala Leu Gln Val Phe Tyr Ile Lys Ser Ile Glu Pro Gln Lys Val  
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 Ser Thr Leu Gly Lys Ser Asn Val Ile Val Thr Gly Ala Asn Phe Thr  
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 Arg Ala Ser Asn Ile Thr Met Ile Leu Lys Gly Thr Ser Thr Cys Asp  
 690 695 700  
 Lys Asp Val Ile Gln Val Ser His Val Leu Asn Asp Thr His Met Lys  
 705 710 715 720  
 Phe Ser Leu Pro Ser Ser Arg Lys Glu Met Lys Asp Val Cys Ile Gln  
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 740 745 750  
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 755 760 765  
 Gly Gln Asn Ile Thr Met Met Gly Arg Asn Phe Asp Val Ile Asp Asn  
 770 775 780  
 Leu Ile Ile Ser His Glu Leu Lys Gly Asn Ile Asn Val Ser Glu Tyr  
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 Cys Val Ala Thr Tyr Cys Gly Phe Leu Ala Pro Ser Leu Lys Ser Ser  
 805 810 815  
 Lys Val Arg Thr Asn Val Thr Val Lys Leu Arg Val Gln Asp Thr Tyr

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850	855	860
Lys Glu Asn Asp Asn Phe Asn Ile Ser Lys Lys Asp Ile Glu Ile Thr		
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880		
Leu Phe His Gly Glu Asn Gly Gln Leu Asn Cys Ser Phe Glu Asn Ile		
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Thr Arg Asn Gln Asp Leu Thr Thr Ile Leu Cys Lys Ile Lys Gly Ile		
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Lys Thr Ala Ser Thr Ile Ala Asn Ser Ser Lys Lys Val Arg Val Lys		
915	920	925
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Trp Tyr Phe Leu Ile Val Leu Pro Val Leu Leu Val Ile Val Ile Phe		
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995	1000	1005
Ser Phe Gly Thr Val Pro Phe Leu Asp Tyr Lys His Phe Ala Leu Arg		
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Thr Phe Phe Pro Glu Ser Gly Gly Phe Thr His Ile Phe Thr Glu Asp		
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Met His Asn Arg Asp Ala Asn Asp Lys Asn Glu Ser Leu Thr Ala Leu		
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Leu Glu Lys Gln Lys Asn Phe Ser Val Lys Asp Arg Cys Leu Phe Ala		
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Ser Phe Leu Thr Ile Ala Leu Gln Thr Lys Leu Val Tyr Leu Thr Ser		
1090	1095	1100

Ile Leu Glu Val Leu Thr Arg Asp Leu Met Glu Gln Cys Ser Asn Met  
 1105 1110 1115 1120  
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 1125 1130 1135  
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 1140 1145 1150  
 Val Gly Glu Pro Phe Tyr Leu Leu Val Thr Thr Leu Asn Gln Lys Ile  
 1155 1160 1165  
 Asn Lys Gly Pro Val Asp Val Ile Thr Cys Lys Ala Leu Tyr Thr Leu  
 1170 1175 1180  
 Asn Glu Asp Trp Leu Leu Trp Gln Val Pro Glu Phe Ser Thr Val Ala  
 1185 1190 1195 1200  
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 Ala Lys Glu Lys Ile Phe Gln Ala Phe Leu Ser Lys Asn Gly Ser Pro  
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 Arg Gln Lys Glu Leu Leu Asp Ile Asp Ser Ser Ser Val Ile Leu Glu  
 1265 1270 1275 1280  
 Asp Gly Ile Thr Lys Leu Asn Thr Ile Gly His Tyr Glu Ile Ser Asn  
 1285 1290 1295  
 Gly Ser Thr Ile Lys Val Phe Lys Lys Ile Ala Asn Phe Thr Ser Asp  
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 Ala Phe Gln Asp Val Gln Gly Lys Arg His Arg Gly Lys His Lys Phe  
 1330 1335 1340  
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 1345 1350 1355 1360  
 Ile His Ser Val Leu Glu Lys Leu Phe Arg Ser Ile Trp Ser Leu Pro  
 1365 1370 1375  
 Asn Ser Arg Ala Pro Phe Ala Ile Lys Tyr Phe Phe Asp Phe Leu Asp  
 1380 1385 1390

Ala Gln Ala Glu Asn Lys Lys Ile Thr Asp Pro Asp Val Val His Ile  
 1395 1400 1405  
 Trp Lys Thr Asn Ser Leu Pro Leu Arg Phe Trp Val Asn Ile Leu Lys  
 1410 1415 1420  
 Asn Pro Gln Phe Val Phe Asp Ile Lys Lys Thr Pro His Ile Asp Gly  
 1425 1430 1435 1440  
 Cys Leu Ser Val Ile Ala Gln Ala Phe Met Asp Ala Phe Ser Leu Thr  
 1445 1450 1455  
 Glu Gln Gln Leu Gly Lys Glu Ala Pro Thr Asn Lys Leu Leu Tyr Ala  
 1460 1465 1470  
 Lys Asp Ile Pro Thr Tyr Lys Glu Glu Val Lys Ser Tyr Tyr Lys Ala  
 1475 1480 1485  
 Ile Arg Asp Leu Pro Pro Leu Ser Ser Ser Glu Met Glu Glu Phe Leu  
 1490 1495 1500  
 Thr Gln Glu Ser Lys Lys His Glu Asn Glu Phe Asn Glu Glu Val Ala  
 1505 1510 1515 1520  
 Leu Thr Glu Ile Tyr Lys Tyr Ile Val Lys Tyr Phe Asp Glu Ile Leu  
 1525 1530 1535  
 Asn Lys Leu Glu Arg Glu Arg Gly Leu Glu Glu Ala Gln Lys Gln Leu  
 1540 1545 1550  
 Leu His Val Lys Val Leu Phe Asp Glu Lys Lys Lys Cys Lys Trp Met  
 1555 1560 1565



# INTERNATIONAL SEARCH REPORT

Internal Application No  
PCT/US 00/24556

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 A61K39/395 A61K38/17 A61P35/00 A61P37/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 C07K A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, BIOSIS

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 32622 A (ZYMOGENETICS INC) 1 July 1999 (1999-07-01) cited in the application page 39, line 25 -page 40, line 17 claims 1-8,28,30 ---	1
X	WO 99 29729 A (TAKASHIMA SEIJI ;KLAGSBRUN MICHAEL (US); MIAO HUA QUAN (US); SOKER) 17 June 1999 (1999-06-17) page 15, line 11 -page 16, line 23 page 22, line 4-7; claims 1,3,4 ---	1
X	WO 99 04263 A (GINTY DAVID D ;KOLODKIN ALEX L (US); UNIV JOHNS HOPKINS (US)) 28 January 1999 (1999-01-28) page 9, line 17 -page 10, paragraph 2 --- -/--	2

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*Z\* document member of the same patent family

Date of the actual completion of the international search

25 January 2001

Date of mailing of the international search report

13/02/2001

Name and mailing address of the ISA

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Fax: (+31-70) 340-3016

Authorized officer

Muller-Thomalla, K

# INTERNATIONAL SEARCH REPORT

Internat. Application No.  
PCT/US 00/24556

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 21997 A (JOHNSON RICHARD S ;SPRIGGS MELANIE KAY (US); IMMUNEX CORP (US); CO) 6 May 1999 (1999-05-06) cited in the application page 3, line 13 -page 4, line 11 ---	2
A	COMEAU M R ET AL: "A poxvirus-encoded semaphorin induces cytokine production from monocytes and binds to a novel cellular semaphorin receptor, VESPR" IMMUNITY,US,CELL PRESS, vol. 8, 1 April 1998 (1998-04-01), pages 473-482, XP002094205 ISSN: 1074-7613 the whole document ---	1,2
A	KOLODKIN A L ET AL: "Neuropilin is a semaphorin III receptor" CELL,CELL PRESS, CAMBRIDGE, NA,US, vol. 90, no. 4, 22 August 1997 (1997-08-22), pages 753-762, XP002084496 ISSN: 0092-8674 the whole document ---	1,2
A	SPRIGGS MELANIE K: "Shared resources between the neural and immune systems: Semaphorins join the ranks." CURRENT OPINION IN IMMUNOLOGY, vol. 11, no. 4, August 1999 (1999-08), pages 387-391, XP002158431 ISSN: 0952-7915 the whole document -----	1,2

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/24556

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